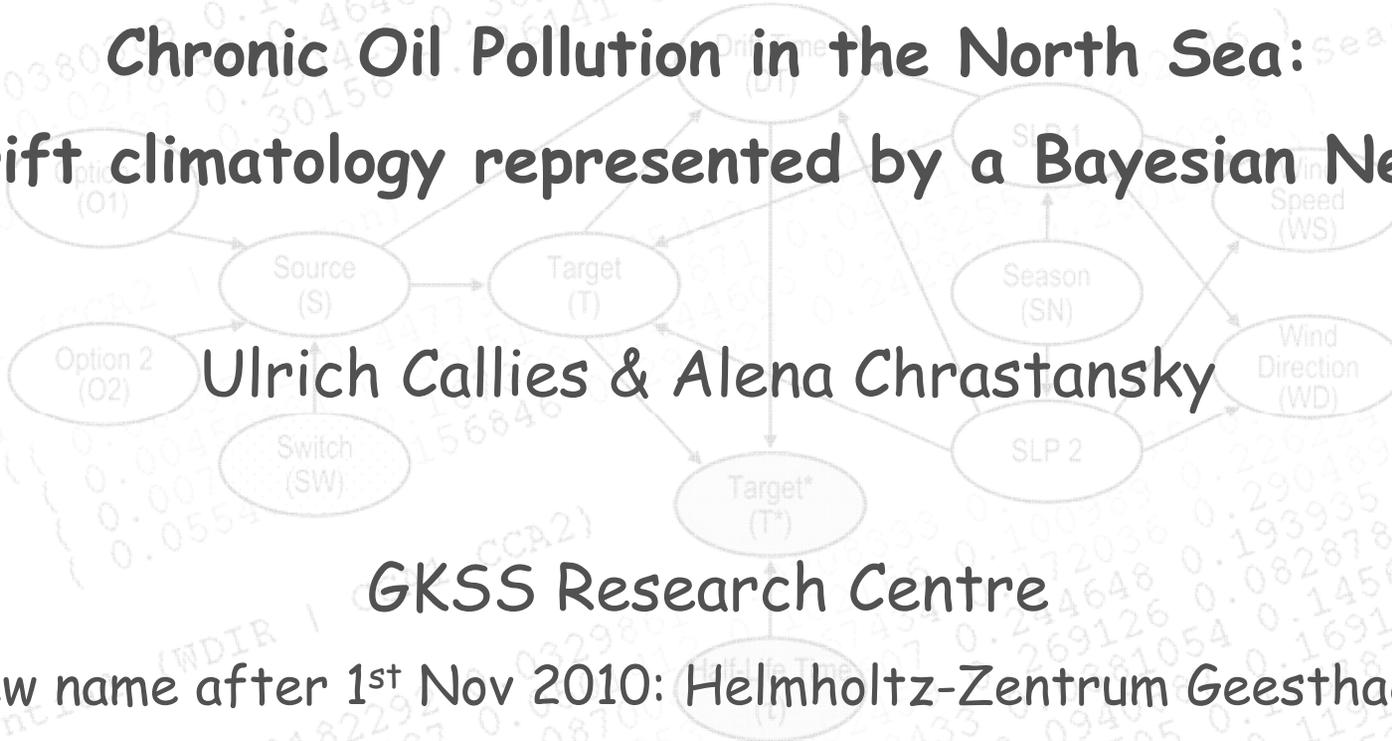


Chronic Oil Pollution in the North Sea: A drift climatology represented by a Bayesian Network

Ulrich Callies & Alena Chrastansky

GKSS Research Centre

(new name after 1st Nov 2010: Helmholtz-Zentrum Geesthacht)



Schedule:

1. Drift Simulations Chronic oil Pollution
2. Bayesian Network (BN) technology
3. BN for Chronic Oil Pollution
4. Demonstration of a Customized Web Application
5. Summary

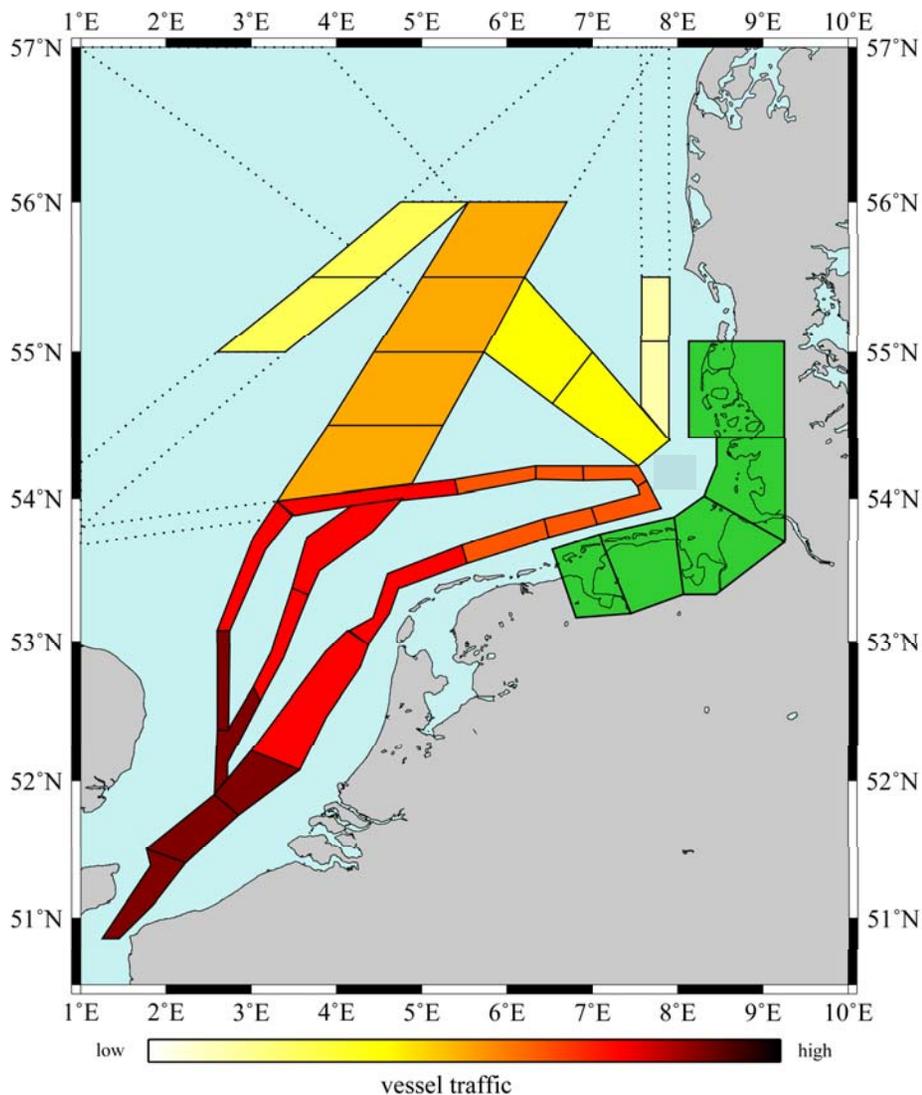
North Sea:

Coastal oil pollution by illegal oil dumping is difficult to quantify

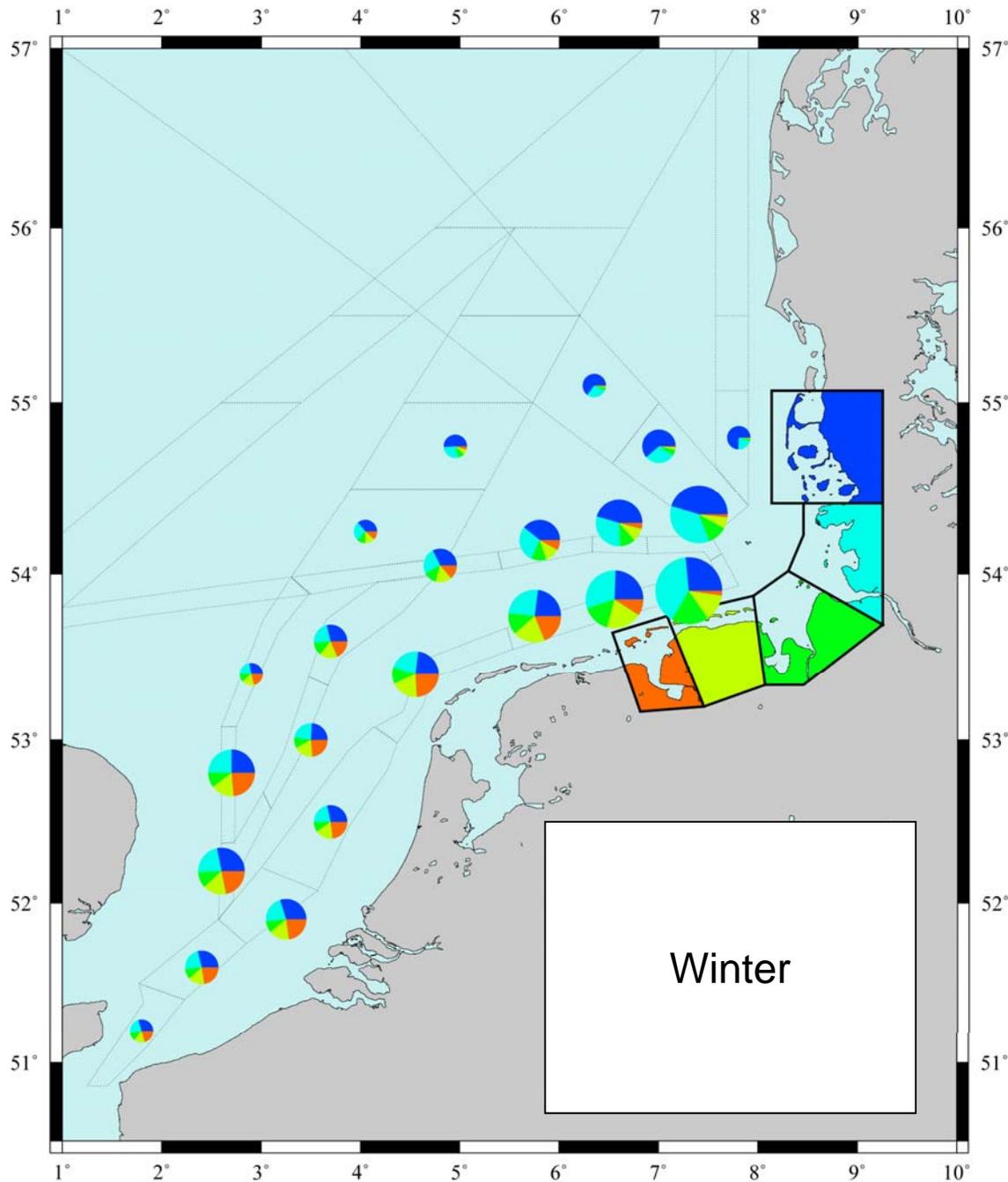


Extensive Drift simulations for estimate of weather driven variability in space and time (Chrastansky & Callies, 2009):

- Drift simulation for hypothetical oil spills every 28 hours (1958-2003)
- Huge amount of data, scientific tools needed for data analysis



- Assumed Source regions: shipping routes, weighting with traffic density
- Atmospheric Forcing and precalculated hydrodynamic currents: www.coastDat.de
- Coastal pollution: tracers hitting the German North Sea coast, half-life 21 days



Published in:

Chrastansky, A. & Callies, U. (2009): Model based long-term reconstruction of weather-driven variations in chronic oil pollution along the German North Sea coast. *Marine Pollution Bulletin*, doi: 10.1016/j.marpolbul.2009.03.009

Chrastansky, A., Callies, U. & Fleet, D.M. (2009): Estimation of the impact of prevailing weather conditions on the occurrence of oil-contaminated dead birds on the German North Sea coast. *Environmental Pollution* 157, 194-198.

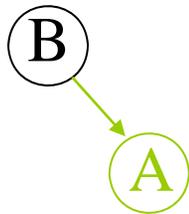
Objectives:

- Probabilistic presentation of the huge ensemble of simulations
- Making data accessible to non-scientific users
- Providing a general framework which allows for combining different types of information (e.g. models, data, expert knowledge)

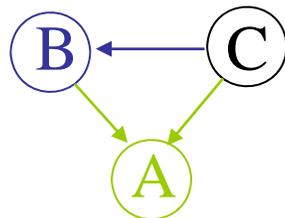
Bayesian Network:

Conditional Probability: $P(A | B) = \frac{P(A, B)}{P(B)}$ (Thomas Bayes, 1763)

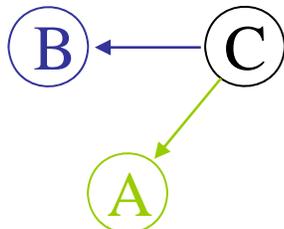
„Bayesians“ consider $P(A | B)$ as being more fundamental than $P(A, B)$



$$P(A, B) = P(A | B) P(B)$$

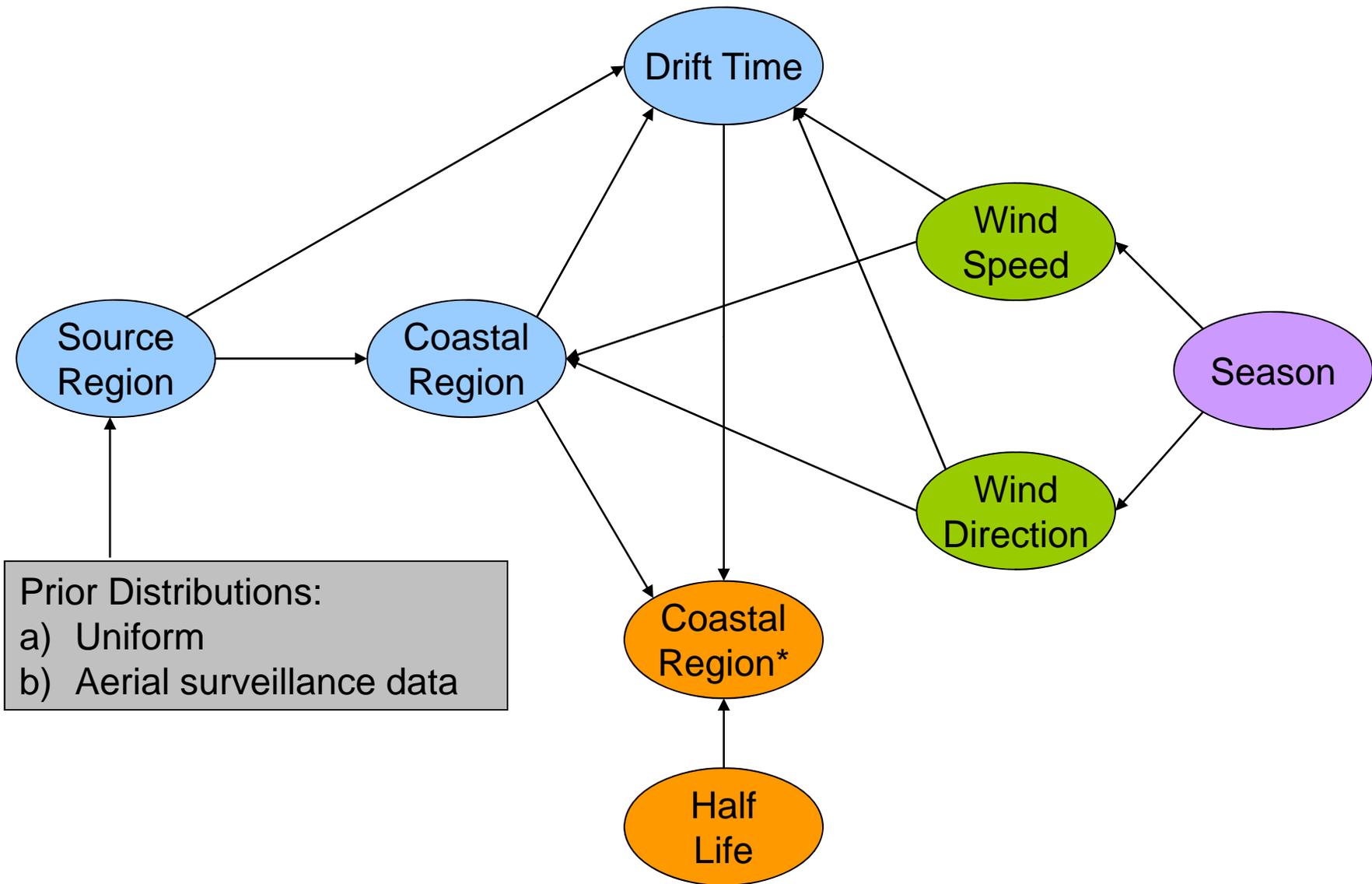


$$P(A, B, C) = P(A | B, C) P(B | C) P(C)$$



Simplified Representation:
Conditional Independence of A and B given C

$$P(A, B, C) = P(A | C) P(B | C) P(C)$$

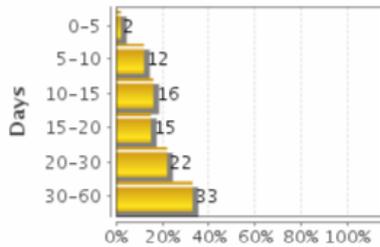


Chronic Oil Pollution in the German Bight: Ensemble Drift Simulations



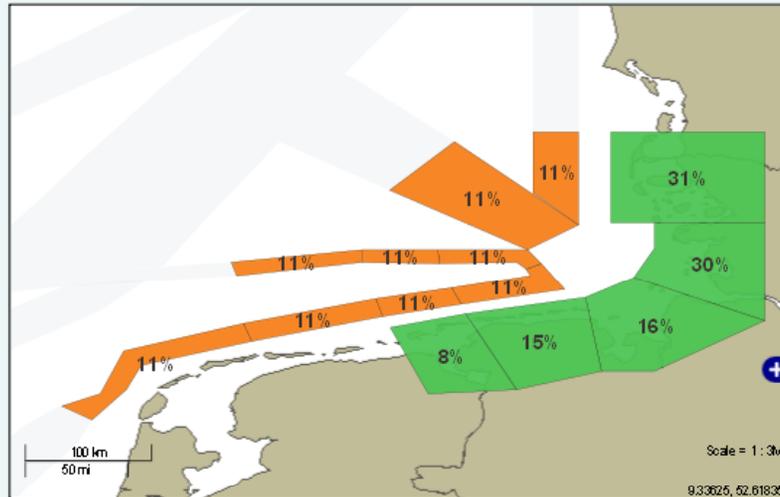
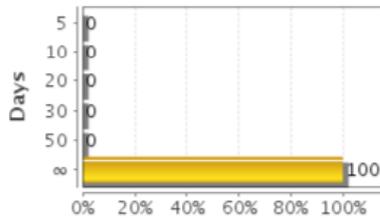
Drift Time

Only particles recorded in receptor regions



Oil Half-life

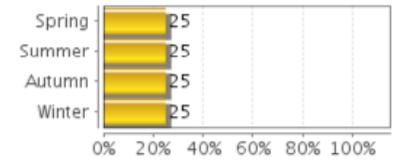
Assumption: No degradation



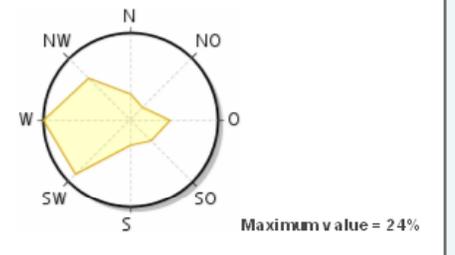
Probability of any receptor region being affected: 54 %.

Basic distribution in the source regions:

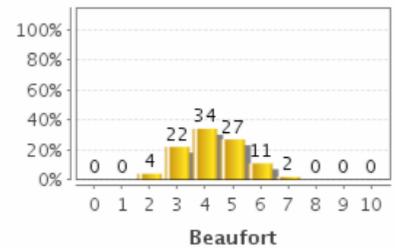
Season



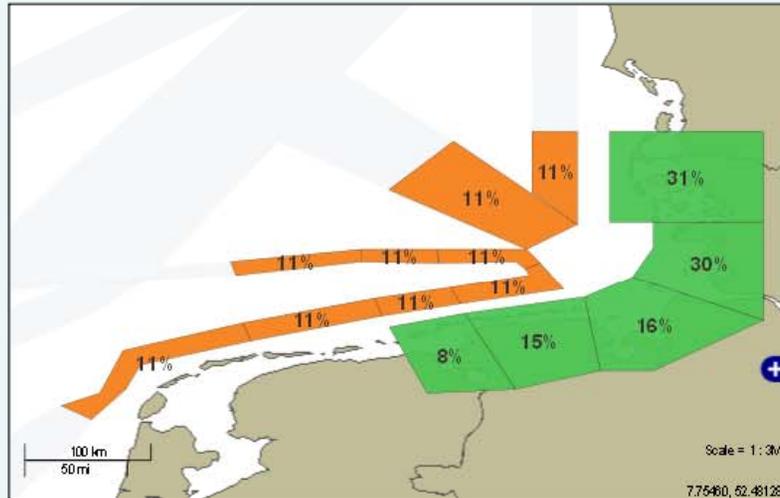
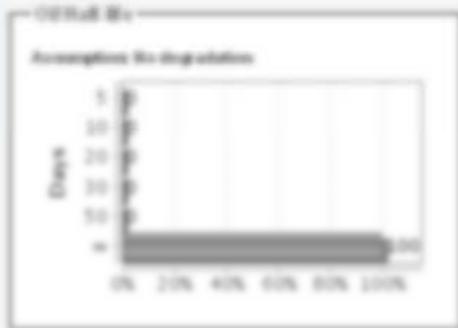
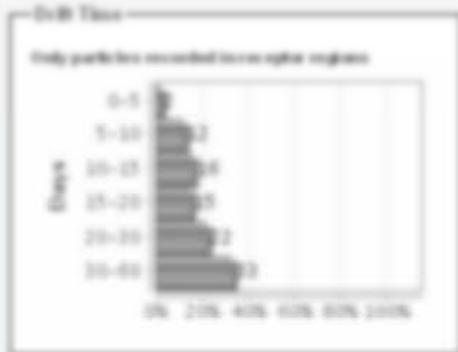
Dominant Wind Direction



Dominant Wind Speed

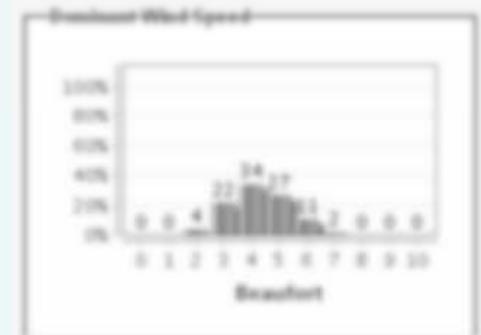
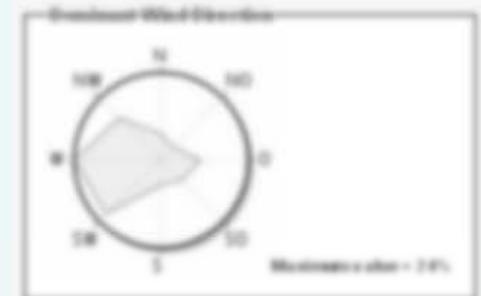
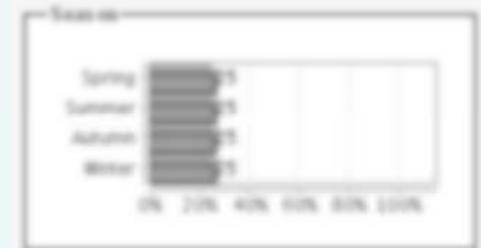


Chronic Oil Pollution in the German Bight: Ensemble Drift Simulations

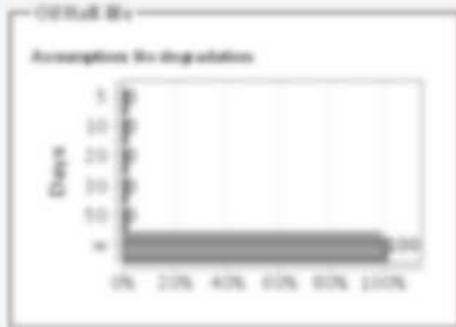
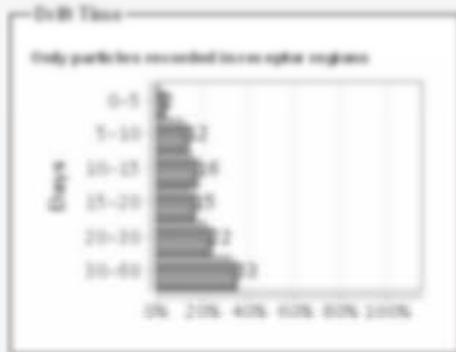


Probability of any receptor region being affected: 54 %.

Basic distribution in the source regions:

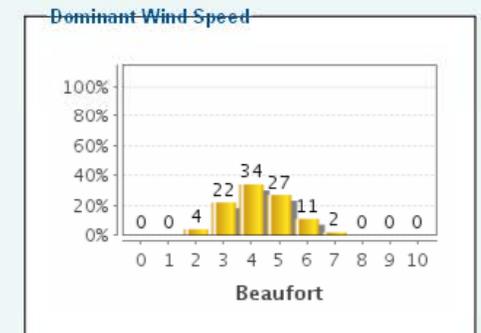
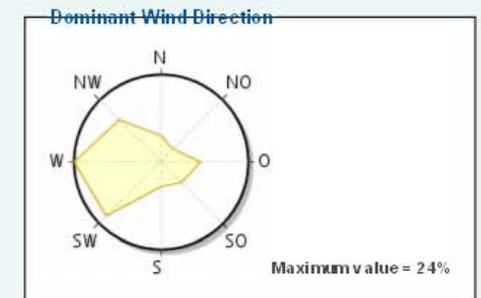
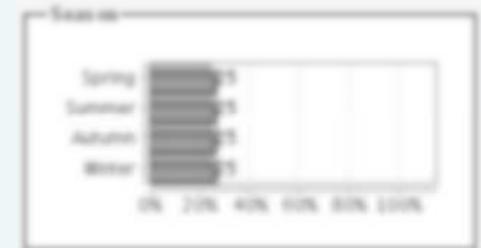


Chronic Oil Pollution in the German Bight: Ensemble Drift Simulations

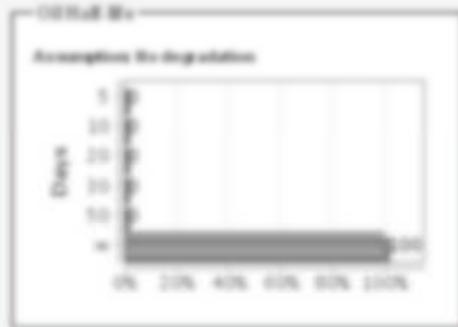
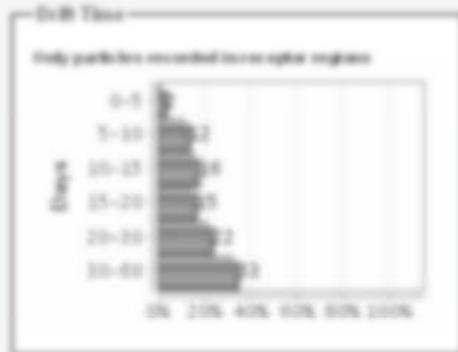


Probability of any receptor region being affected: 34 %

Scale: Distribution in the receptor regions: Uniform distribution

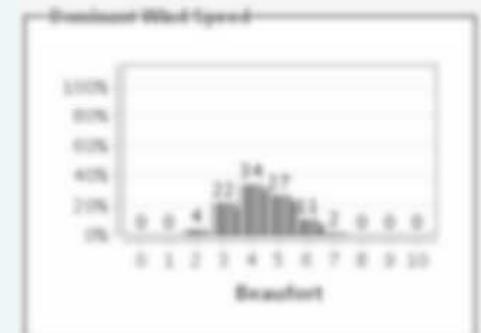
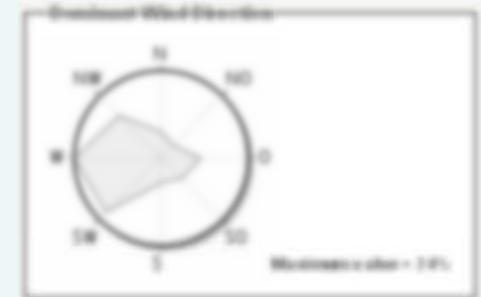
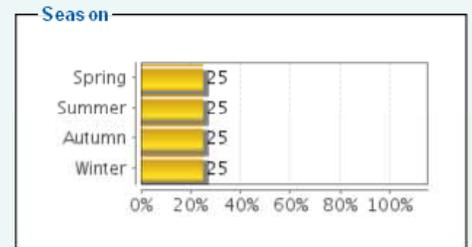


Chronic Oil Pollution in the German Bight: Ensemble Drift Simulations



Probability of any receptor region being affected: 34 %

Scale: Distribution in the receptor regions:

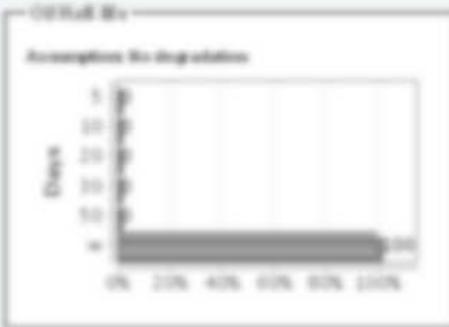
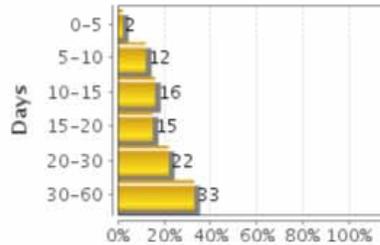


Chronic Oil Pollution in the German Bight: Ensemble Drift Simulations



Drift Time

Only particles recorded in receptor regions

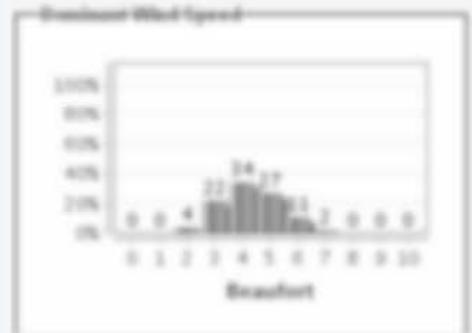
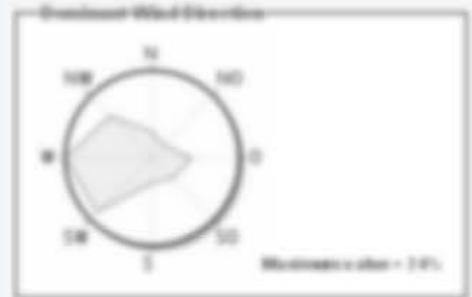
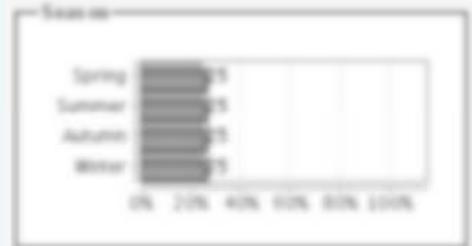


Probability of any receptor region being affected: 34 %

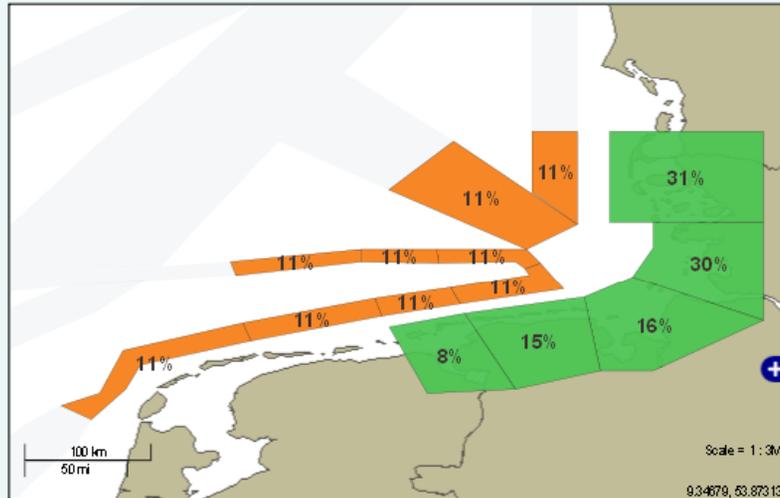
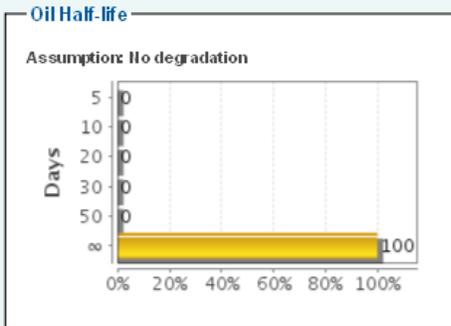
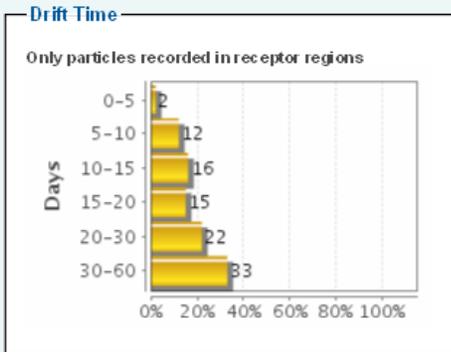
Scale: Distribution in the receptor regions: Uniform distribution

Help Reset Initial State Calculate

<< < Save > >>

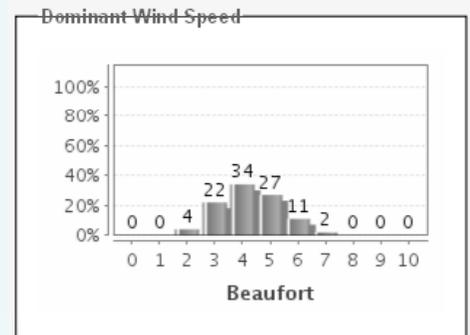
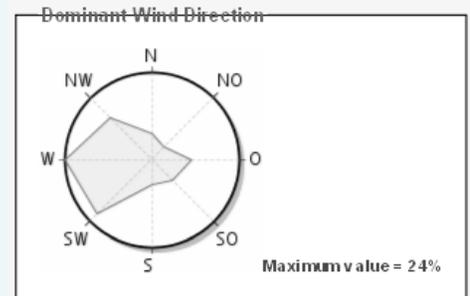
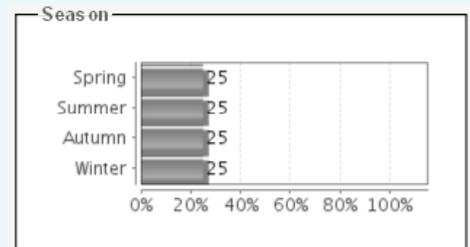


Chronic Oil Pollution in the German Bight: Ensemble Drift Simulations

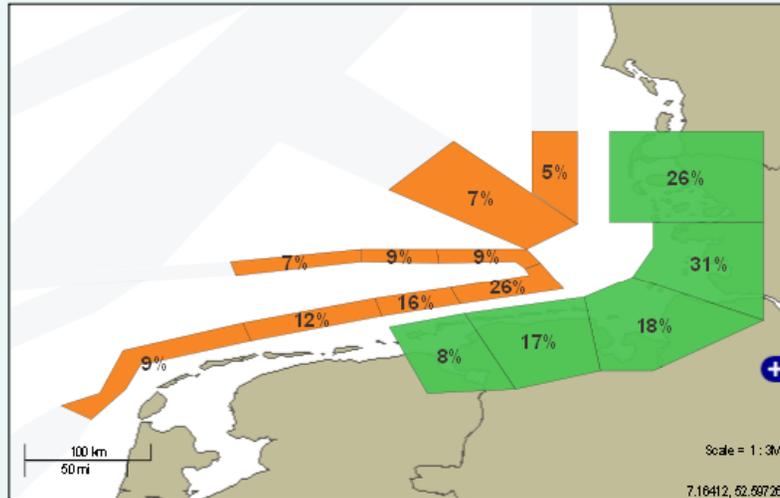
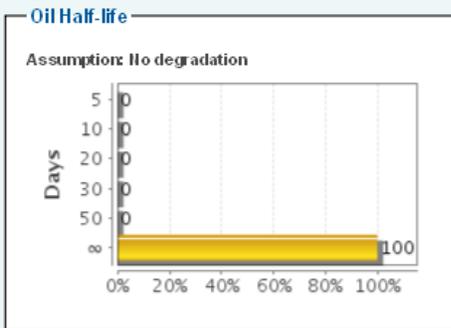
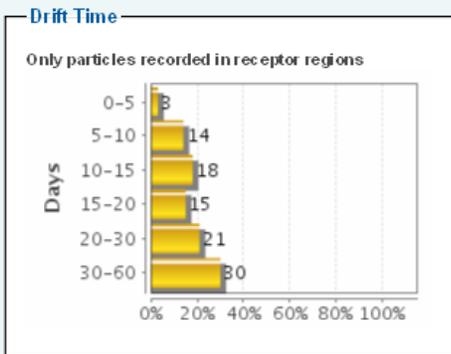


Probability of any receptor region being affected: 54% ← **54%**

Basic distribution in the source regions:

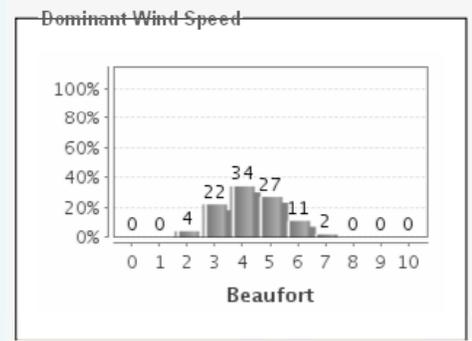
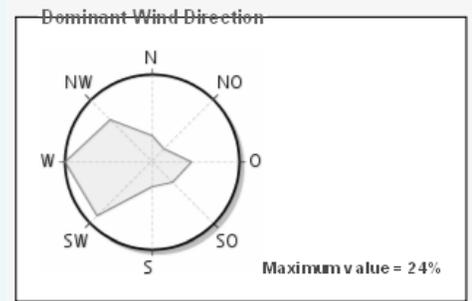
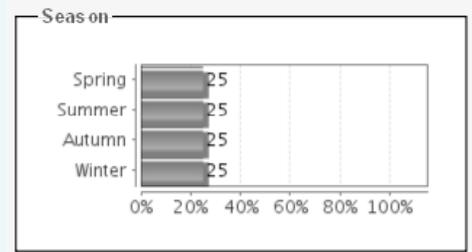


Chronic Oil Pollution in the German Bight: Ensemble Drift Simulations



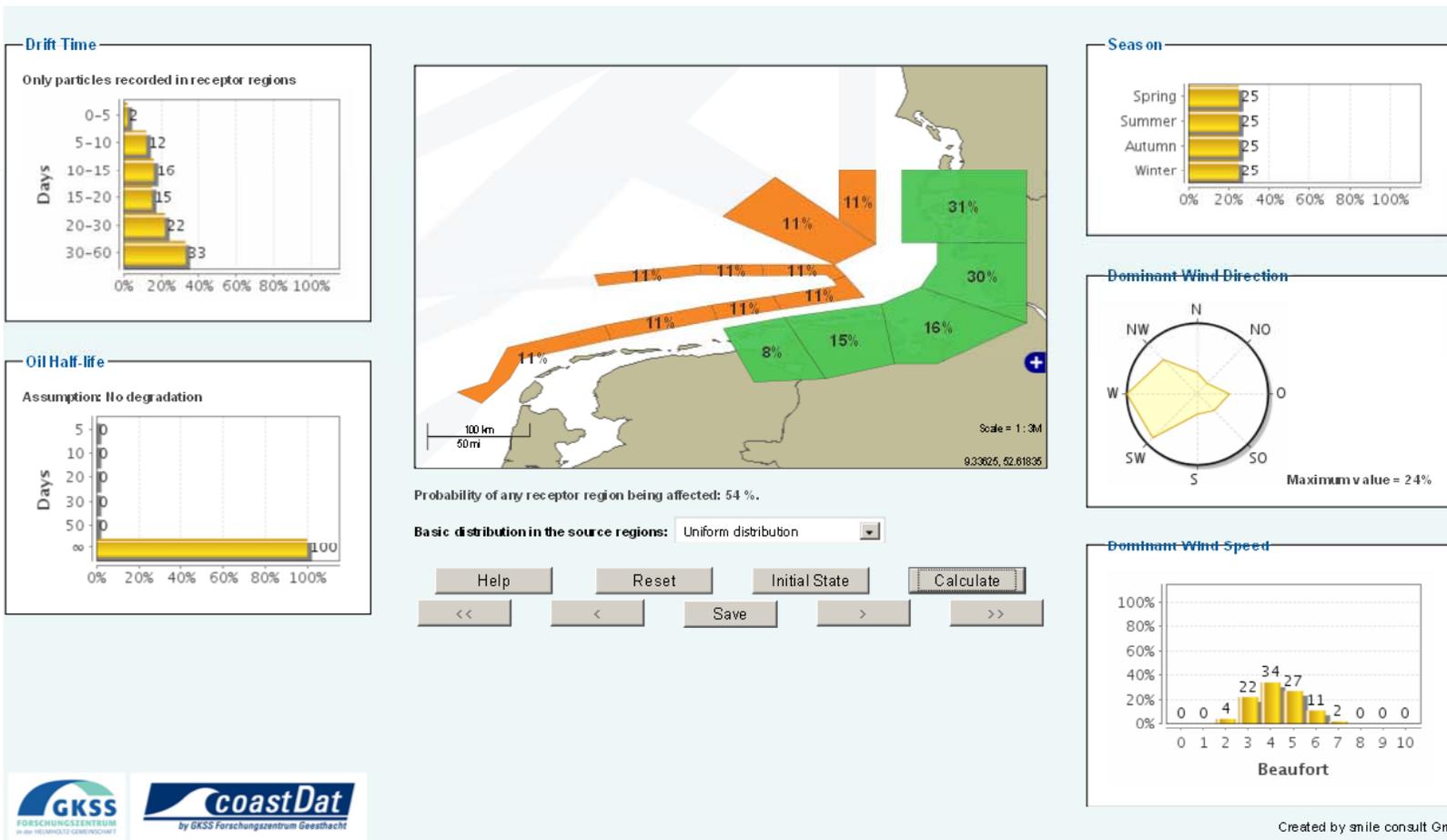
Probability of any receptor region being affected: 59% ← **59%**

Basic distribution in the source regions:



No prior information about probable sources (i.e. uniform prior distribution of sources)

- ↳ Selected target region
- ↳ Half Life: $\tau = 10$ days
- ↳ Data from aerial surveillance
- ↳ Release in given source region A
- ↳ Release in given source region B
- ↳ Focus on summer season
- ↳ Focus on wind direction NW



No prior information about probable sources (i.e. uniform prior distribution of sources)

↳ Assume pollution in coastal region -> Probabilities for release in different source regions

↳ Half Life: $\tau = 10$ days

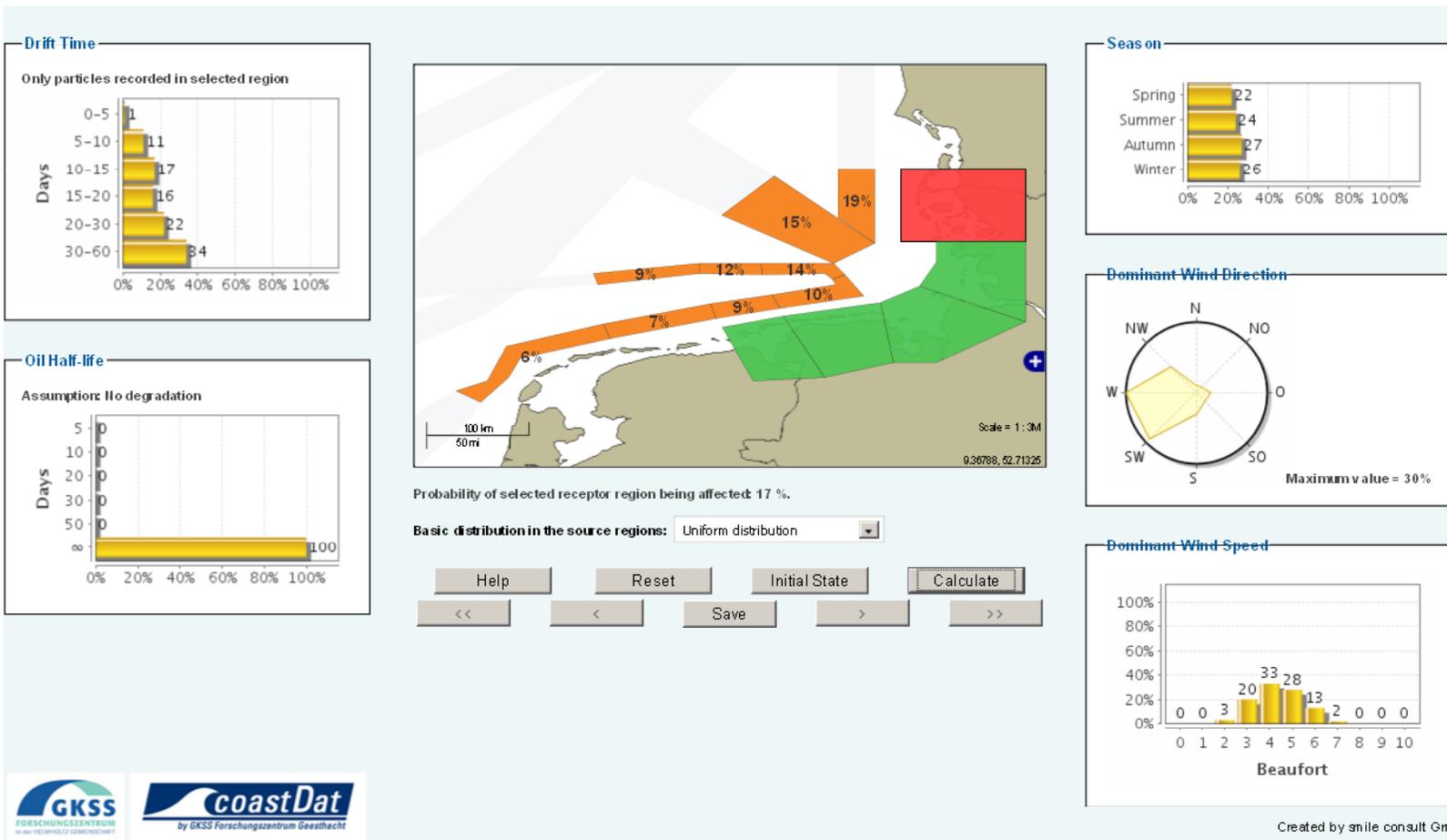
↳ Data from aerial surveillance

↳ Release in given source region A

↳ Release in given source region B

↳ Focus on summer season

↳ Focus on wind direction NW

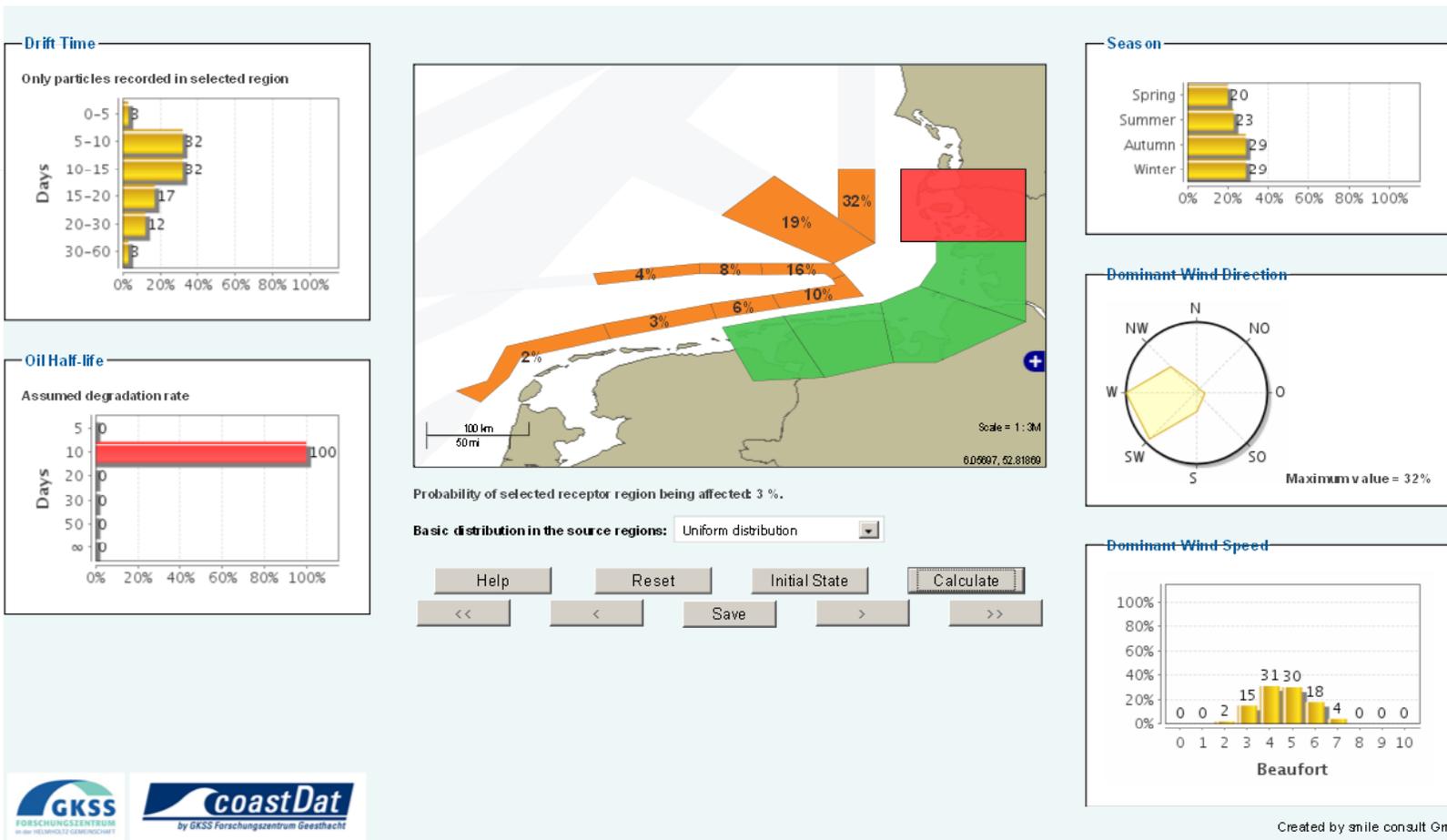


No prior information about probable sources (i.e. uniform prior distribution of sources)

↳ Assume pollution in coastal region -> Probabilities for release in different source regions

↳ Half Life: $\tau = 10$ days (characterization of substance)

- ↳ Data from aerial surveillance
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No prior information about probable sources (i.e. uniform prior distribution of sources)

↳ Assume pollution in coastal region -> Probabilities for release in different source regions

↳ Half Life: $\tau = 10$ days (characterization of substance)

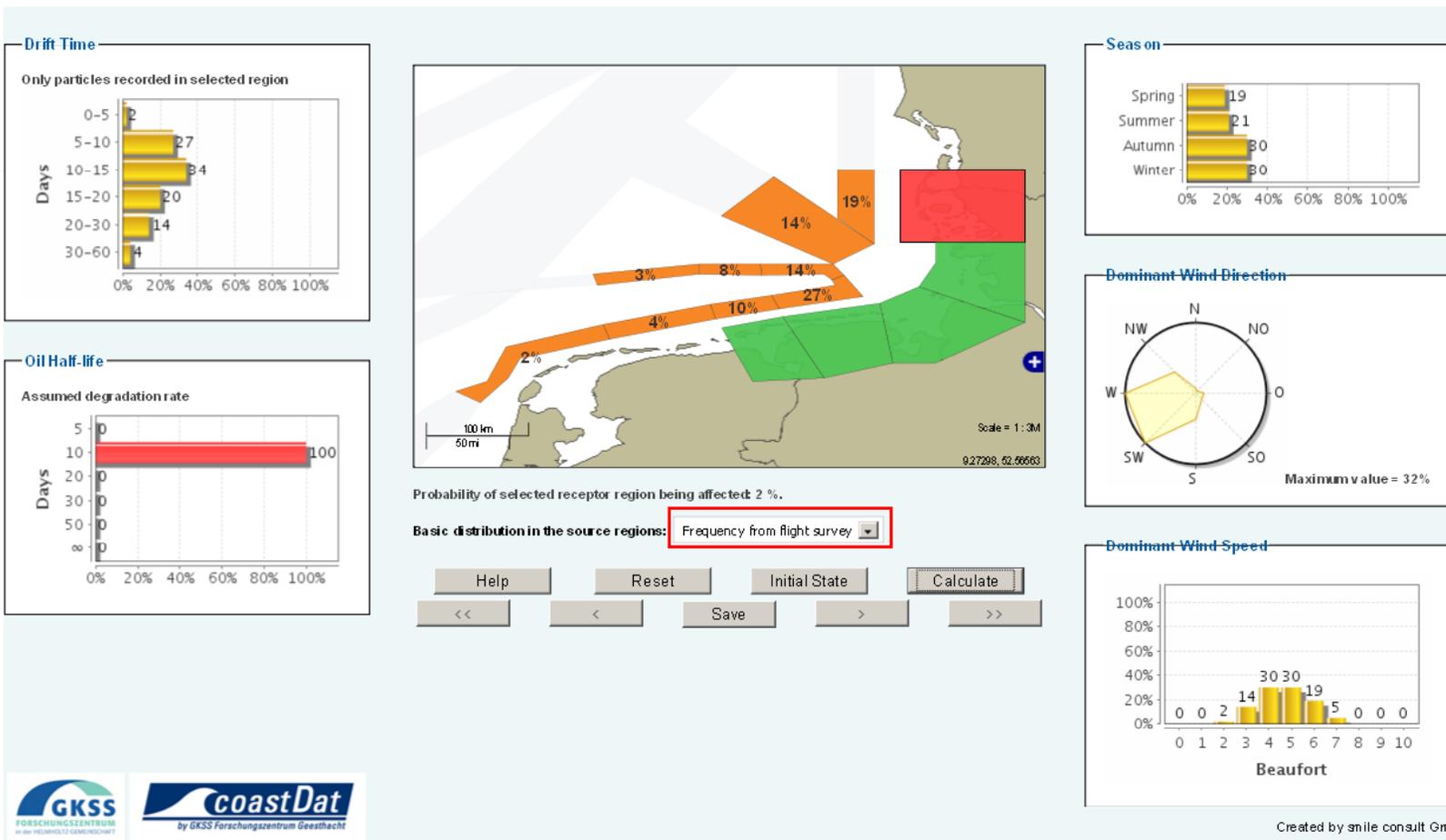
↳ Assume prior distribution of sources according to aerial surveillance data

↳ Release in given source region A

↳ Release in given source region B

↳ Focus on summer season

↳ Focus on wind direction NW



No prior information about probable sources (i.e. uniform prior distribution of sources)

↳ Assume pollution in coastal region -> Probabilities for release in different source regions

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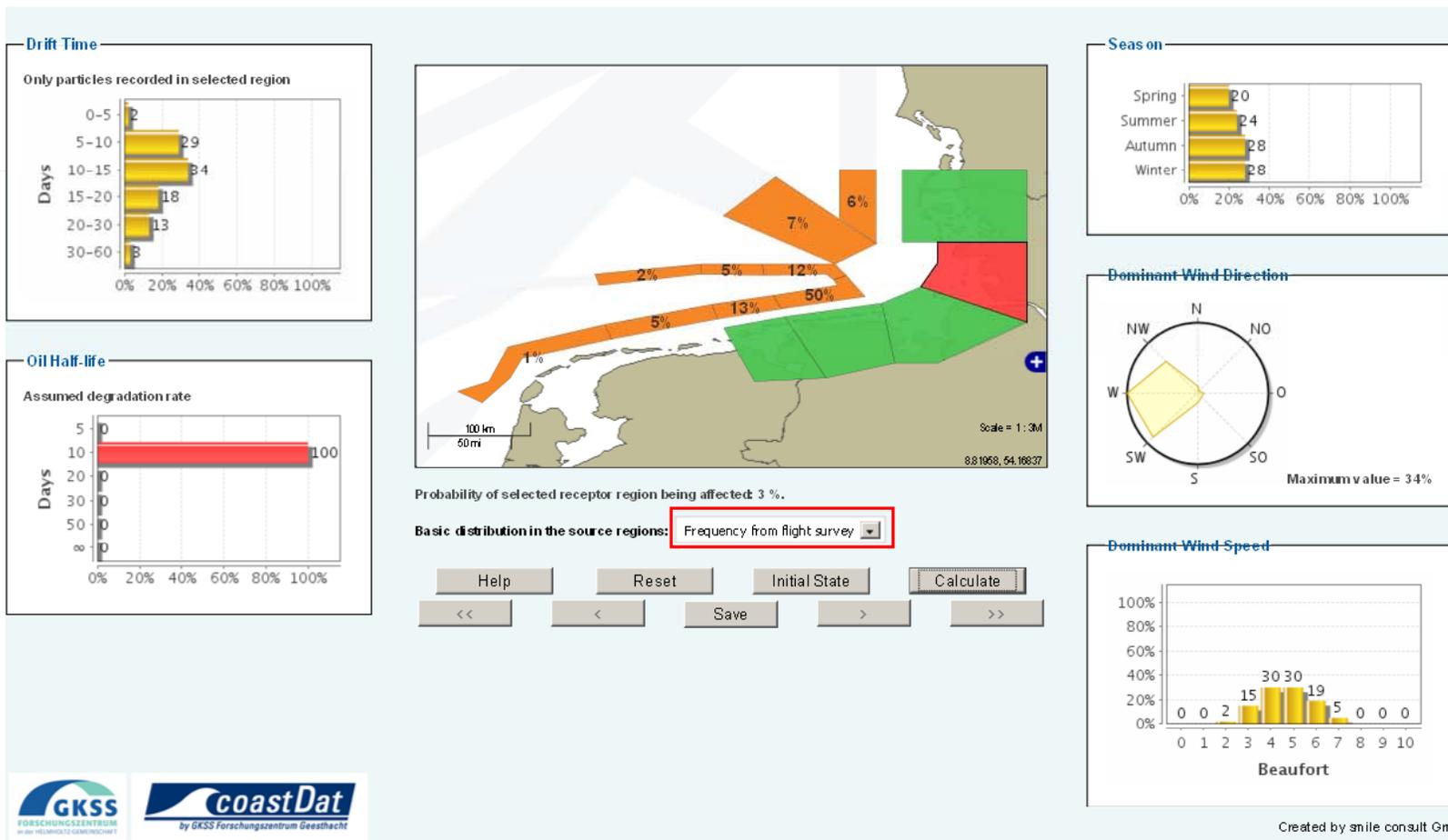
↳ Assume prior distribution of sources according to aerial surveillance data

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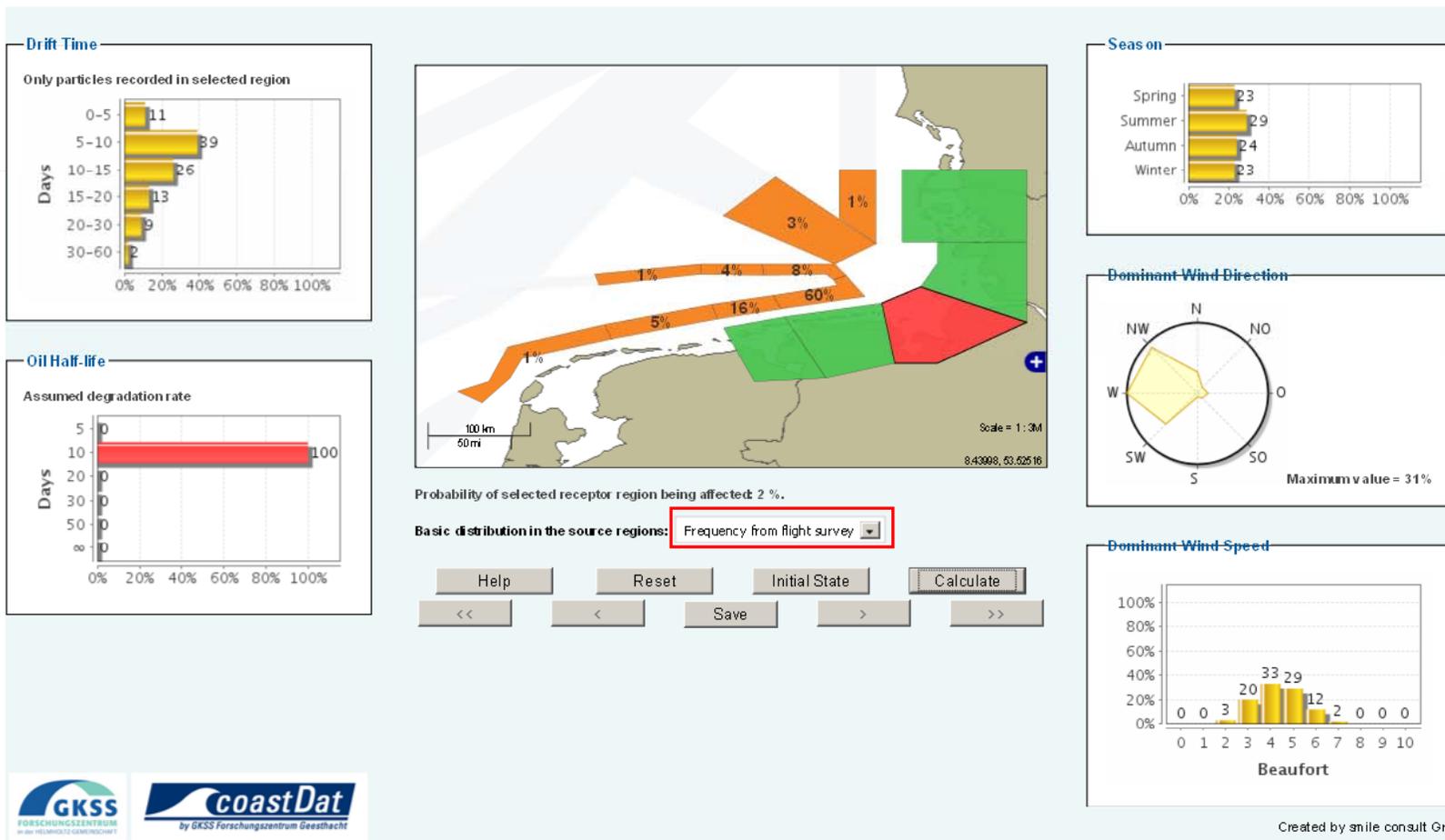
↳ Assume prior distribution of sources according to aerial surveillance data

↳ Release in given source region A

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No prior information about probable sources (i.e. uniform prior distribution of sources)

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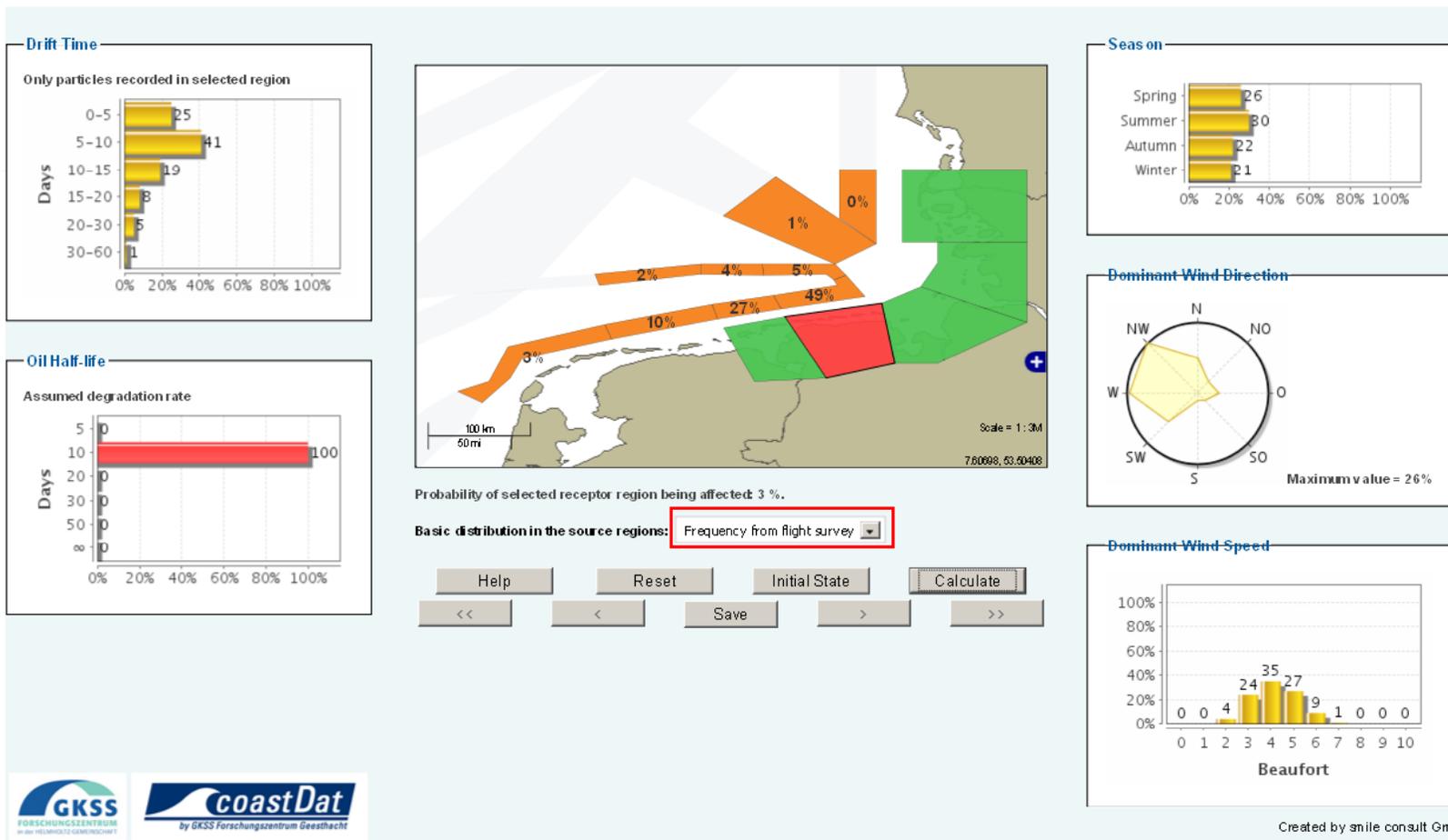
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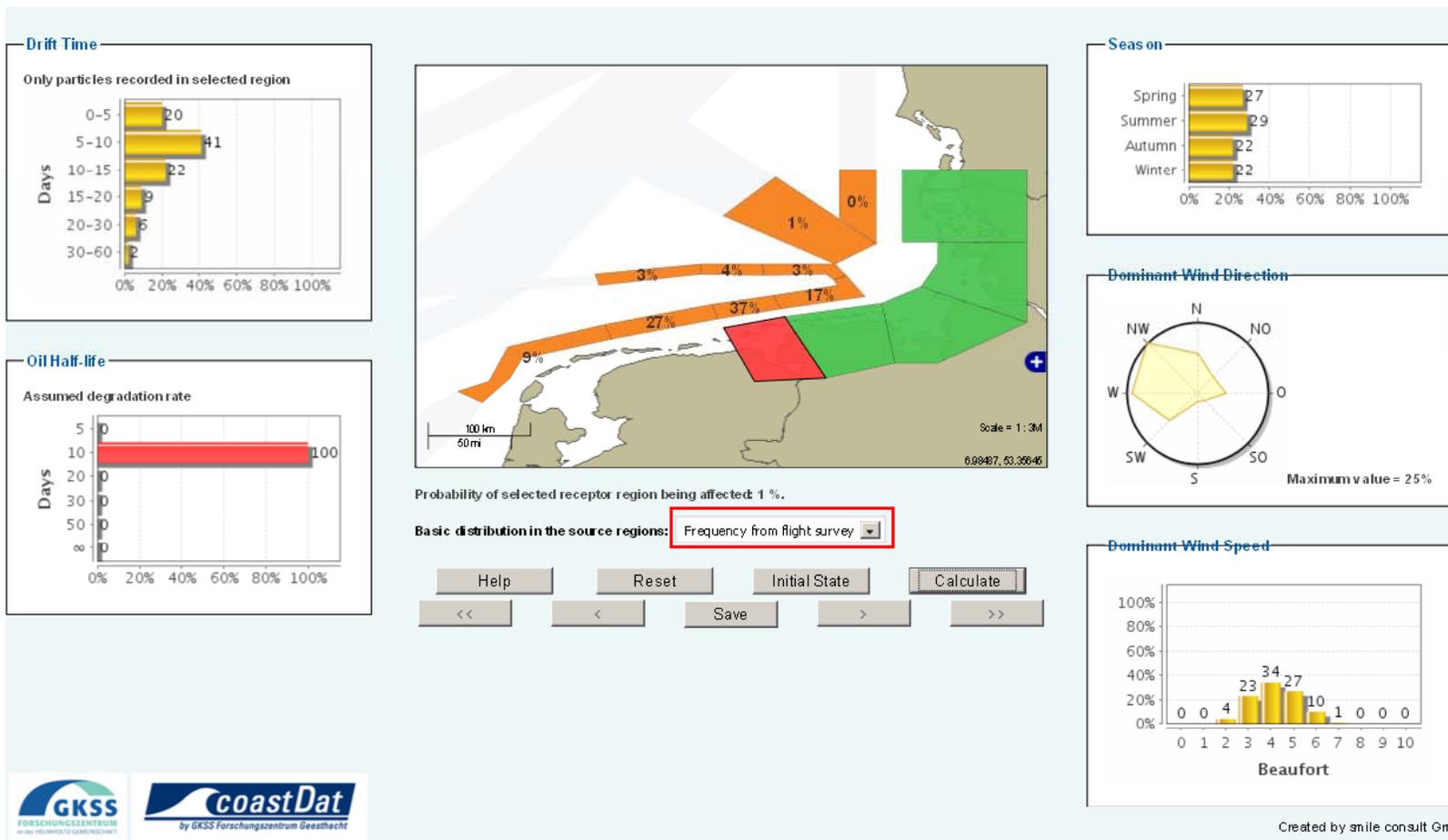
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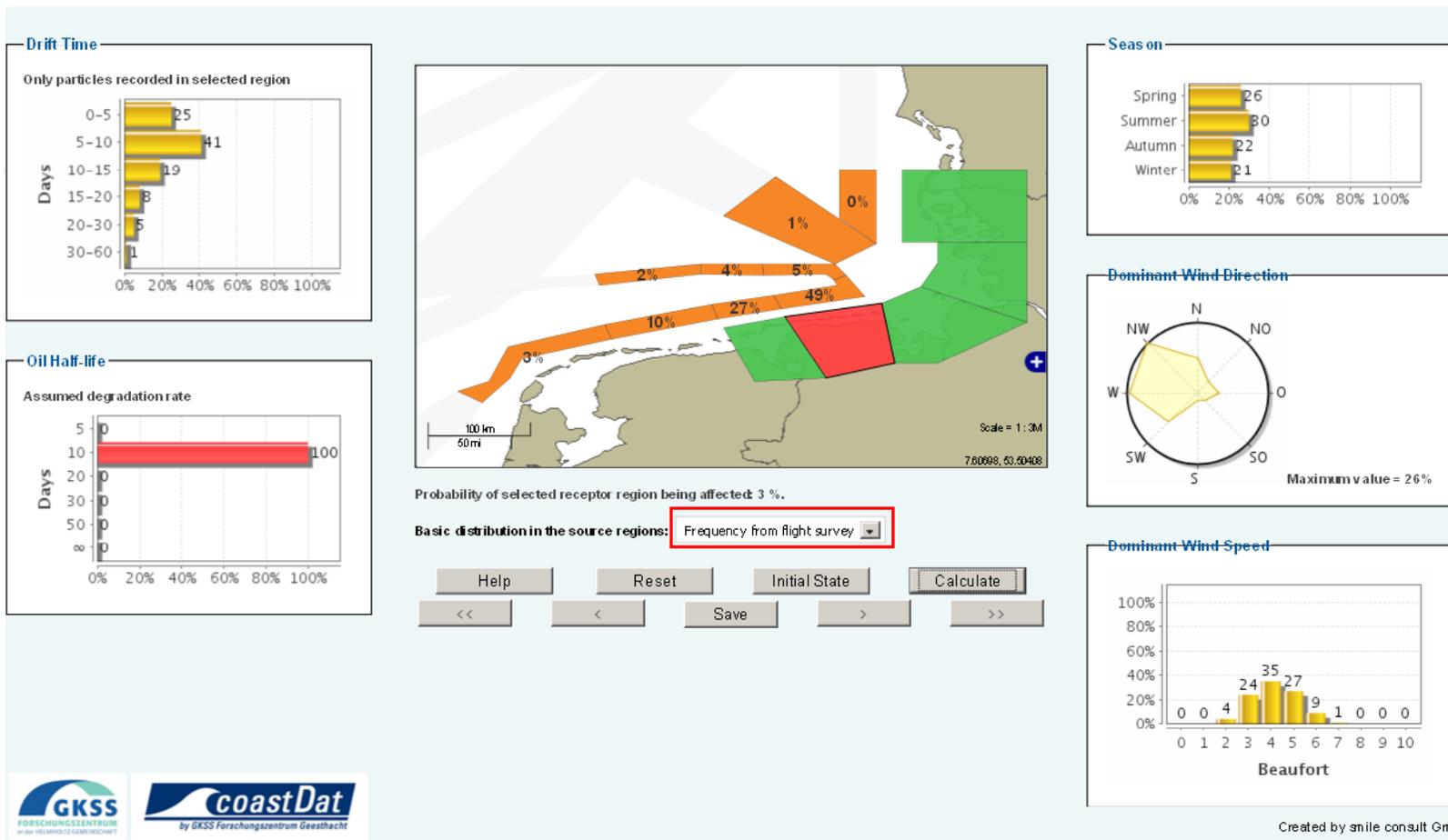
↳ Assume prior distribution of sources according to aerial surveillance data

↳ Release in given source region A

↳ Release in given source region B

↳ Focus on summer season

↳ Focus on wind direction NW



No prior information about probable sources (i.e. uniform prior distribution of sources)

↳ Assume pollution in coastal region -> Probabilities for release in different source regions

↳ Half Life: $\tau = 10$ days (characterization of substance)

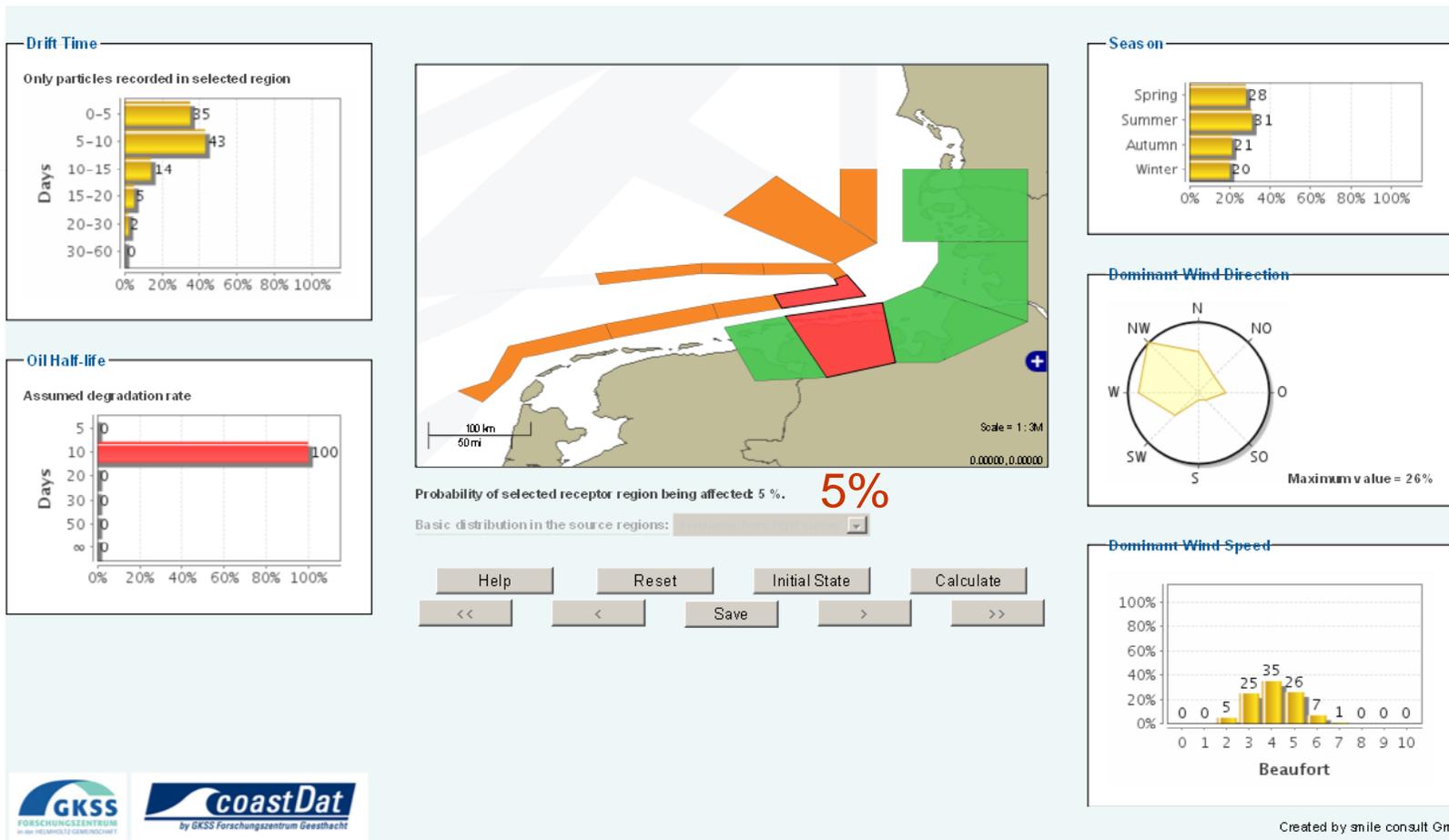
↳ Assume prior distribution of sources according to aerial surveillance data

↳ Assume release in given source region A (near the coast)

↳ Release in given source region B

↳ Focus on summer season

↳ Focus on wind direction NW



No prior information about probable sources (i.e. uniform prior distribution of sources)

↳ Assume pollution in coastal region -> Probabilities for release in different source regions

↳ Half Life: $\tau = 10$ days (characterization of substance)

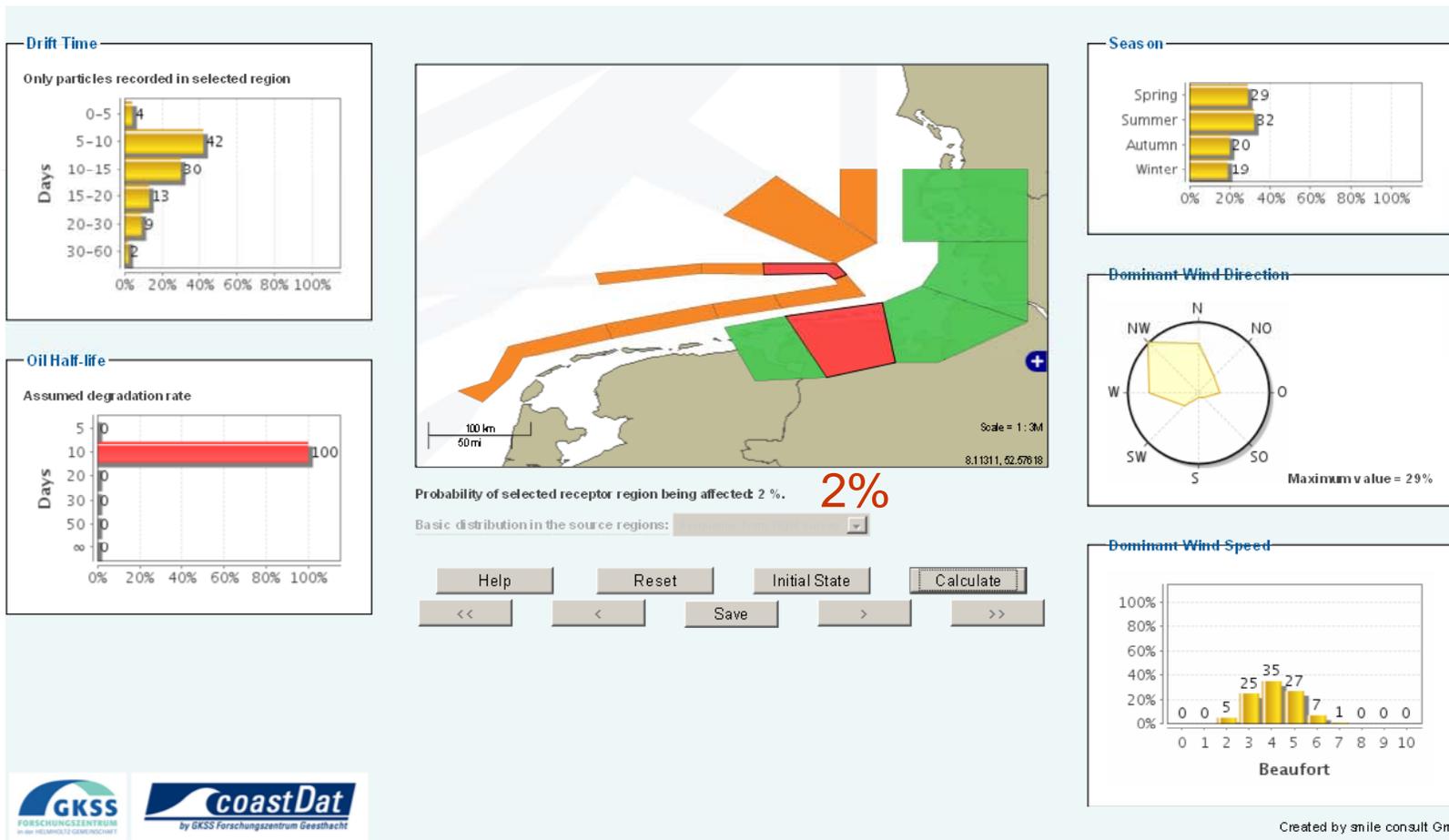
↳ Assume prior distribution of sources according to aerial surveillance data

↳ Assume release in given source region A (near the coast)

↳ Assume release in given source region B (more offshore)

↳ Focus on summer season

↳ Focus on wind direction NW



No prior information about probable sources (i.e. uniform prior distribution of sources)

↳ Assume pollution in coastal region -> Probabilities for release in different source regions

↳ Half Life: $\tau = 10$ days (characterization of substance)

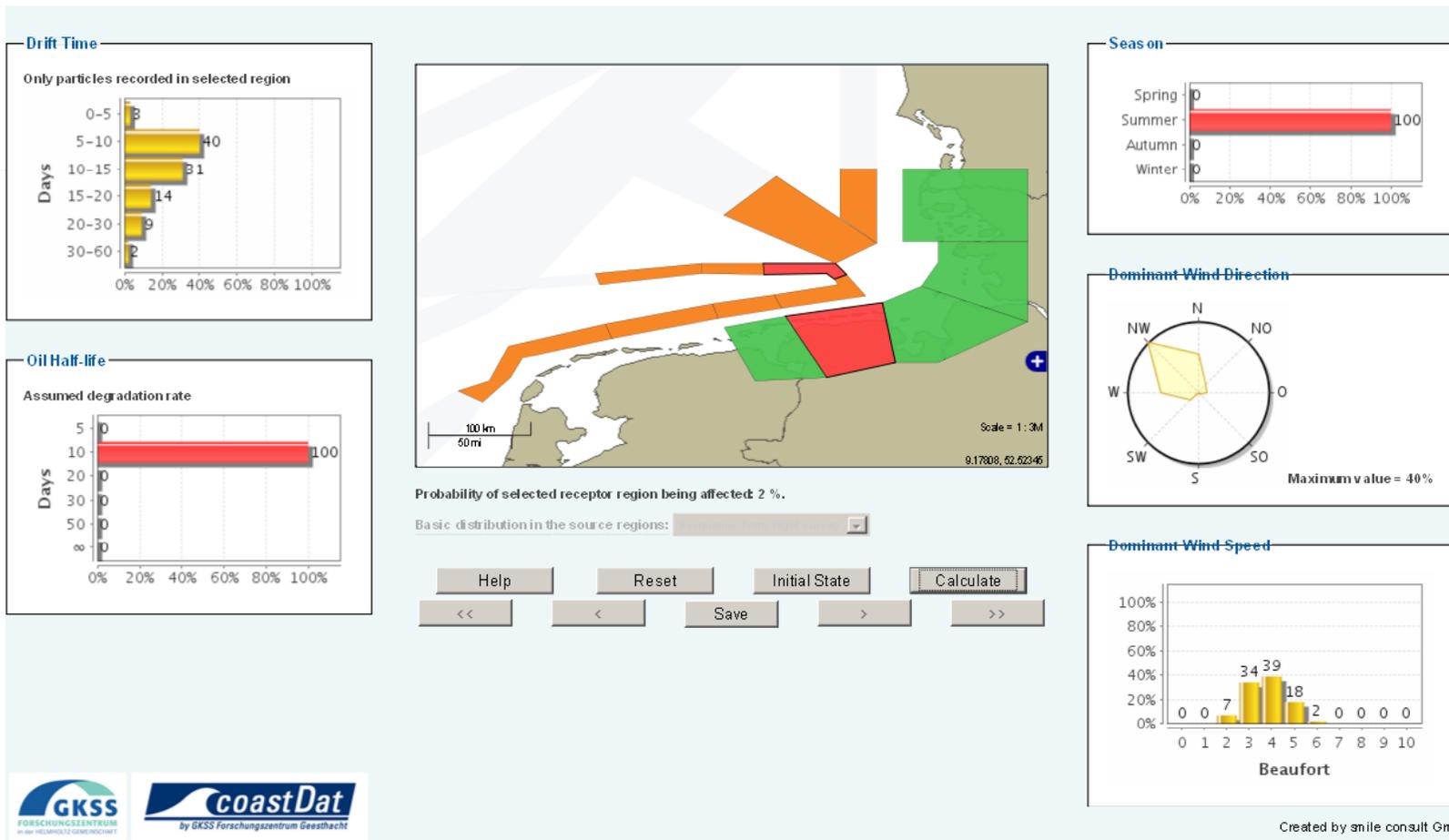
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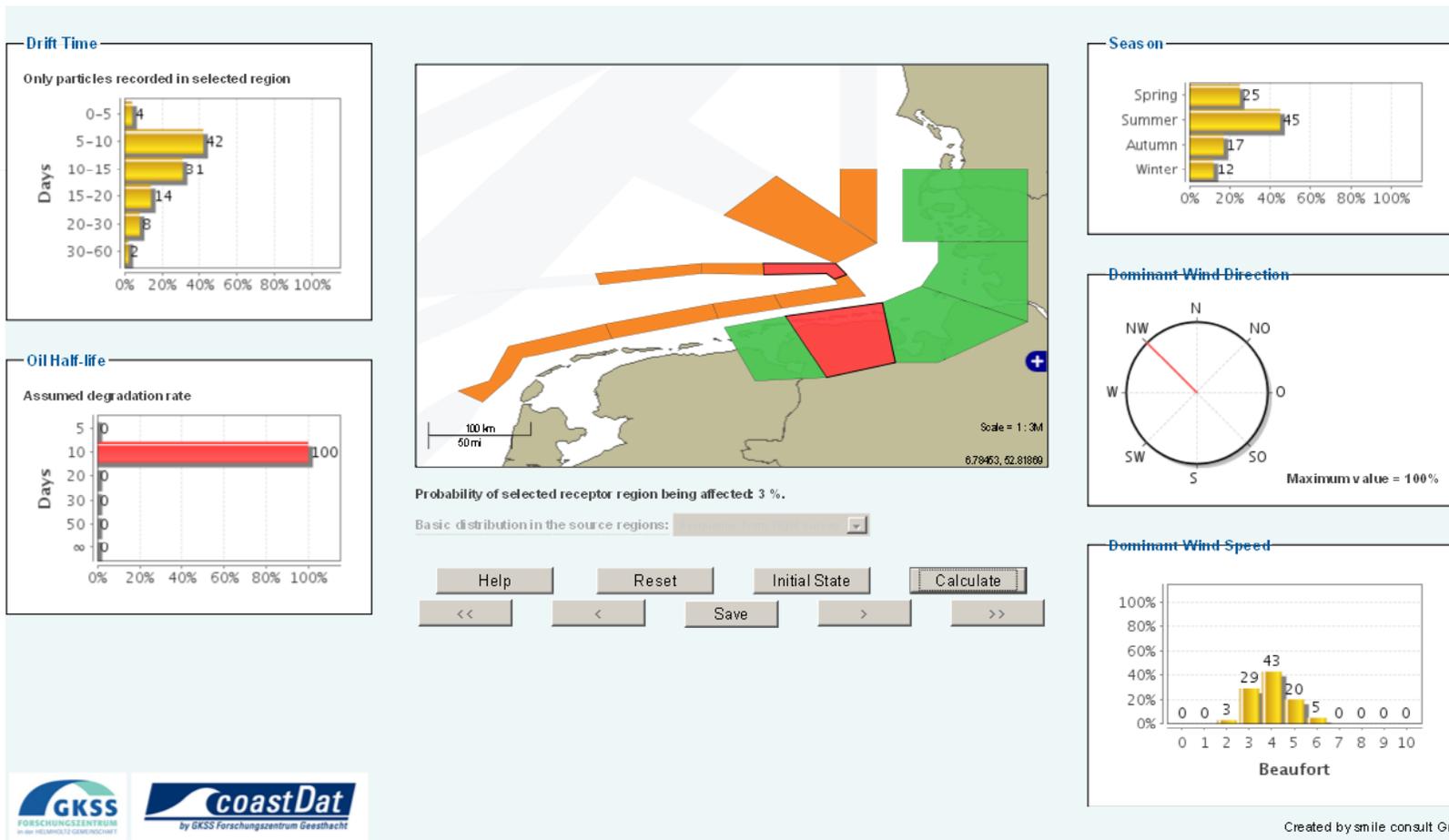
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Summary

- Long term ensemble simulations → huge data bases
- BNs capture the main interactions in the data in terms of conditional probabilities
- They do not need access to these original data (except for calibration)
- Essential parameter interactions can be explored on any small computer (convenient access also for non-scientific decision makers)
- Combination of numerical model results with other data possible, e.g.
 - probability distribution of source strengths
 - oil properties (half-life)
 - ecosystem sensitivity depending on season
 - probability of oil release dependent on weather conditions?

Link to the Bayesian network:

www.coastdat.de/oil_pollution

THANK YOU FOR YOUR ATTENTION!