NAUTILOS

Coastal Simulation Experiments Supporting NAUTILOS New Observing Methodologies

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The NAUTILOS project

NAUTILOS is an H2020 project with the objective of filling marine observation and modelling gaps for chemical, biological and deep ocean physics variables through the development of a new generation of cost-effective sensors and samplers, the integration of these technologies within observing platforms, and their deployment in large-scale demonstrations in European seas. The goal is to democratize monitoring capacities of the marine environment, making it widely available to both traditional and non-traditional data users. The global activities of NAUTILOS project are presented in Figure 1.

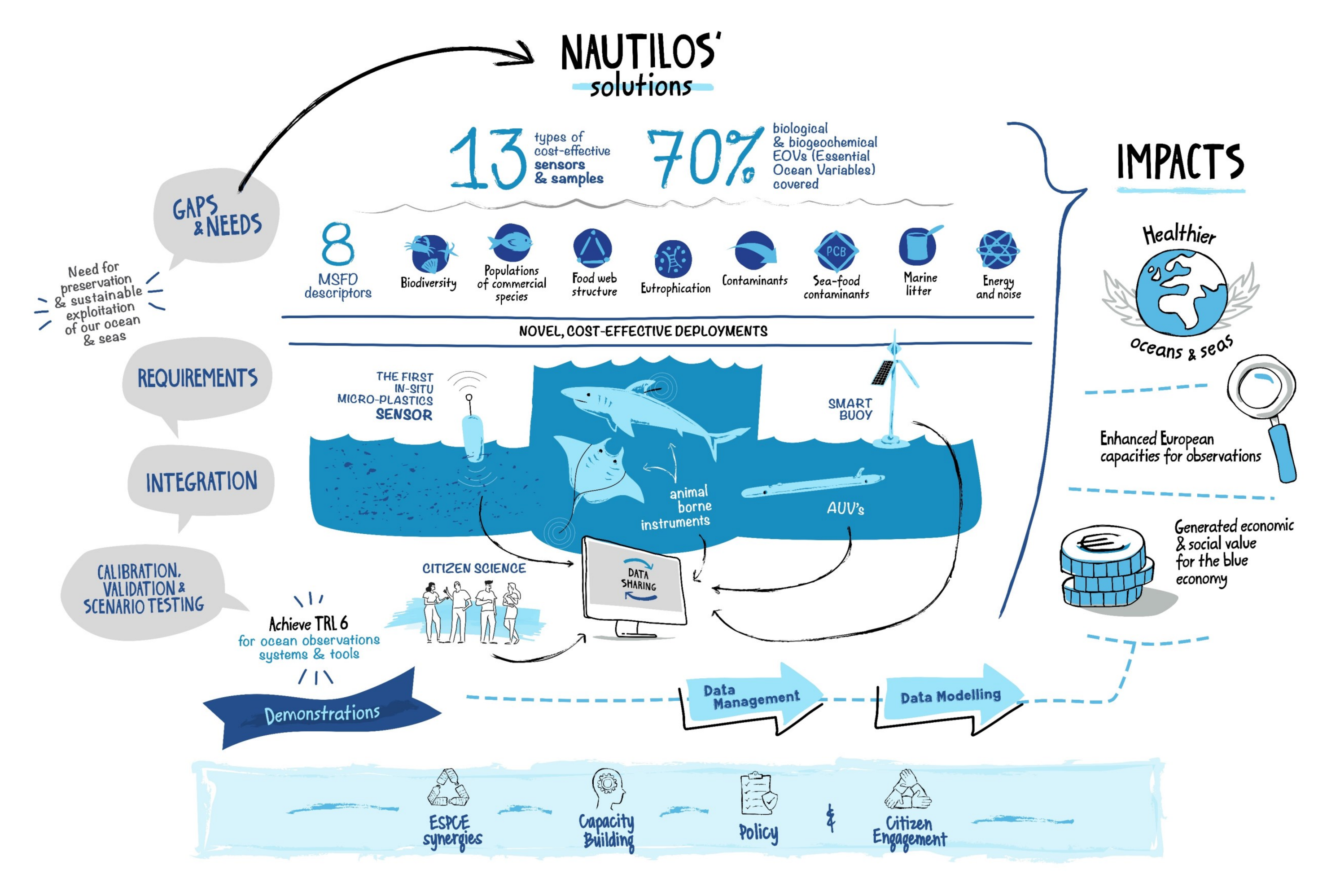


Figure 1: General infographics of the NAUTILOS project

The OSSE in NAUTILOS

A central activity of this project is to evaluate the effectiveness of these newly available low-cost technologies on the capacity of coastal numerical forecasting of physical, chemical, and biological variables. To answer this question, a set of Observing System Simulation Experiments (OSSE) of the "fraternal twins" type is being prepared in three different European coastal areas with distinct meteoceanographic conditions. The general methodology for OSSE implementation is depicted in Figure 2. The "pre-Nautilos" and "post-Nautilos" simulation experiments will be compared against Nature Run (NR) to assess improvements. a Free Run (FR) is used as control.

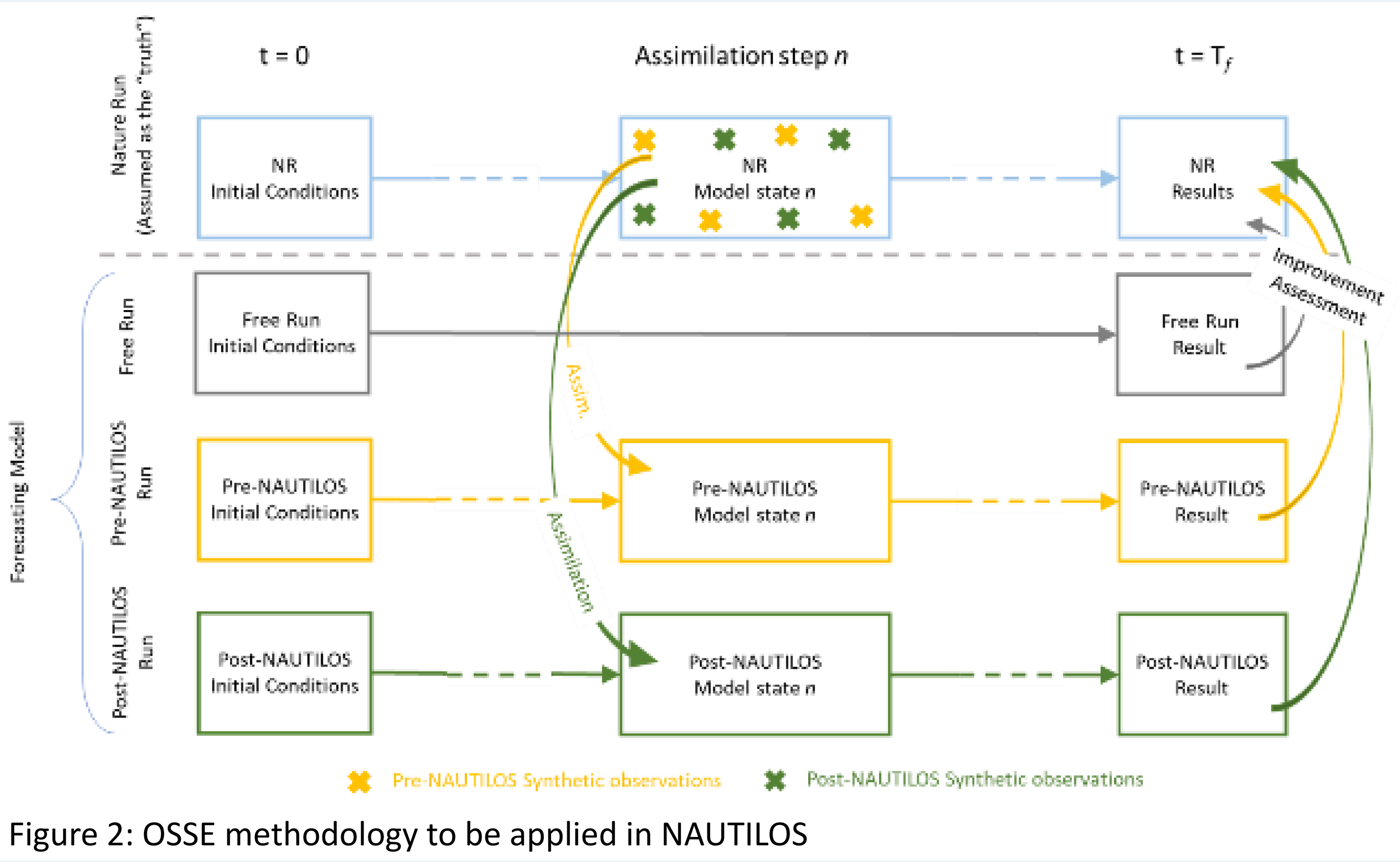


Figure 2: OSSE methodology to be applied in NAUTILOS

Assessment Methodology

Model improvements are assessed using several different metrics. Many indicators and metrics have been proposed for that purpose (e.g., Murphy, 1988, Taylor, 2001, Liu and Weisberg, 2011), along with more traditional assessment methodologies (e.g., RMSE analysis). Since the three sites possess different characteristics, the appropriate metrics can vary from site to site, nevertheless a common methodology is set in place using the indicators of Figure 3.

Spatially Integrated Averages and Standard Deviations

$$AVG(t_i) = \frac{\sum_{domain} \theta(t_i)}{N}$$

$$STD(t_i) = \sqrt{\frac{\sum_{domain} \left(\theta(t_i) - AVG(t_i)\right)^2}{N}}$$

Temporally Integrated Averages and Standard deviations

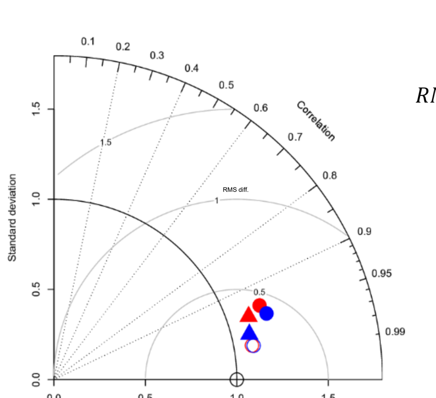
$$AVG(i,j,k) = \frac{\sum_{t_i=0}^{T} \theta(i,j,k)}{N}$$

$$STD(i,j,k) = \sqrt{\frac{\sum_{t_i=0}^{T} \left(\theta(i,j,k) - AVG(i,j,k)\right)^2}{T}}$$

Spatially Integrated RMSD

$$RMSD(t_i) = \sqrt{\frac{\sum_{domain} \left(\theta_f(t_i) - \theta_{NR}(t_i)\right)^2}{N}}$$

Taylor Diagram



Temporally Integrated RMSD

$$RMSD(i,j,k) = \sqrt{\frac{\sum_{t_i=0}^{T} \left(\theta_f(i,j,k) - \theta_{NR}(i,j,k)\right)^2}{T}}$$

Murphy Skill Score Map

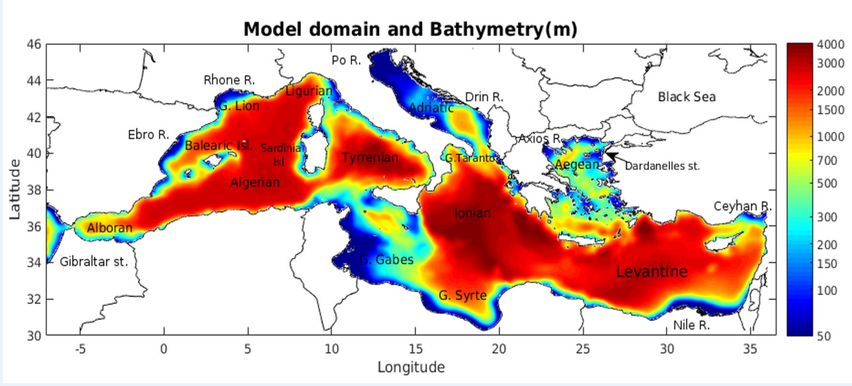
$$\Sigma = \rho^2 - \left[\rho - \frac{\sigma_f}{\sigma_{NR}}\right]^2 - \left[\frac{(\bar{\theta}_f - \bar{\theta}_{NR})}{\sigma_{NR}}\right]^2$$

Figure 3: Common assessment methodology for the OSSE in NAUTILOS

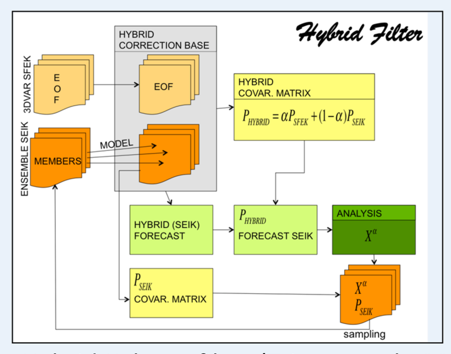
The three systems addressed

Three different European coastal areas are used to demonstrate the impact of NAUTILOS technologies: the Mediterranean Sea, the SW Iberian Coast and the Hardangerfjord in Norway. Physical, biogeochemical and plastic drifting models are combined and applied in these sites.

Mediterranean Sea

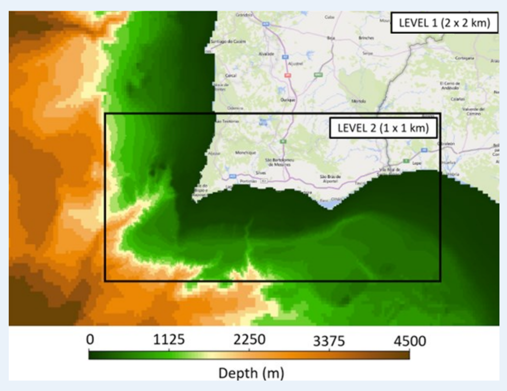


Hydrodynamic model: POM (Blumberg and Mellor, 1983)
Data assimilation: Sea level altimetry & sea surface temperature (hybrid ensemble Kalman, Tsiaras et al., 2017)
Biogeochemical model: ERSEM-II (Baretta et al., 1995, Kalaroni et al., 2020)
Carbonate chemistry: Haltafall (Blackford et al., 2007)

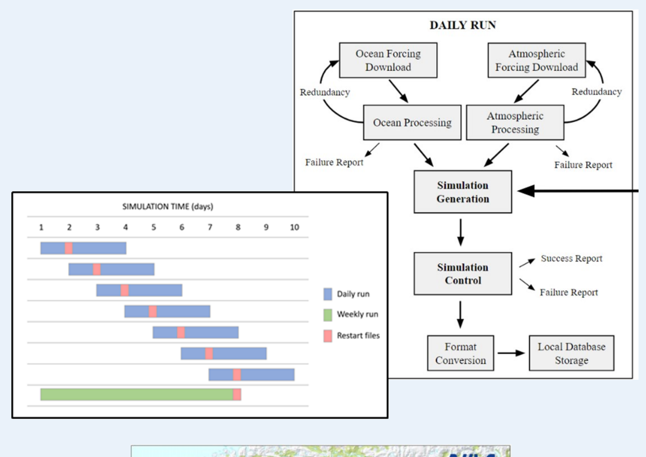


Hybrid Kalman filter (Tsiaras et al., 2017)

SW Iberia

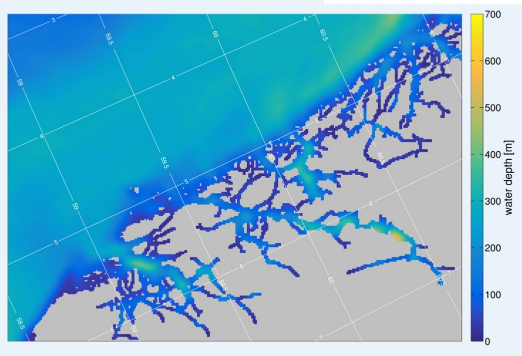


Hydrodynamic Model: MOHID Modelling System
Bathymetric Data: EMODNET
2 nested grids: Level 1: 2 km (1.3x10[6] cells)
Level 2: 1 km (1.4x10[6] cells)
Hybrid vertical grid geometry:
11 sigma layers at the top 20 m
35 Z layers below 20 m
Surface layer thickness:75 cm
Boundaries:
Atmosphere: SKIRON (POSEIDON)
Open Boundaries CMEMS

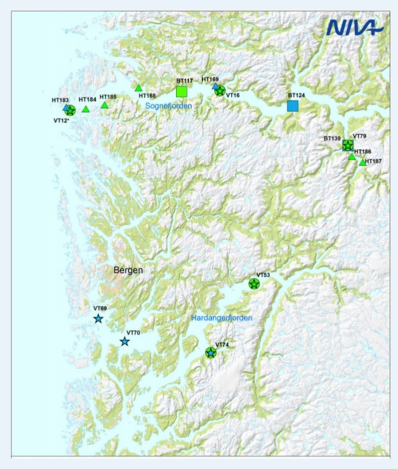


(Janeiro et al., 2017)

Hardanger Fjord

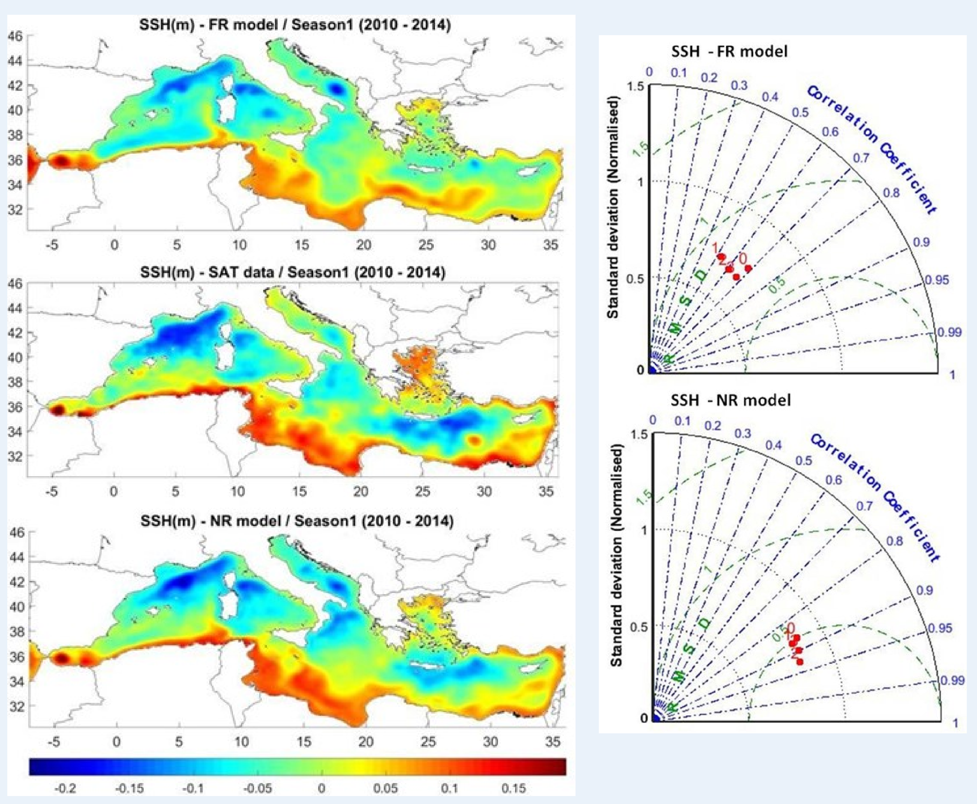


Hydrodynamic Model:
ROHO800 based on ROMS with IS4DVAR assimilation
Biogeochemical Model:
ERSEM (adapted for Nordic plankton species and extended to account for light spectral quality + cDOM interactions)
Grid Geometry:
800m cartesian
Boundaries:
Copernicus GLORYS12V1 ocean lateral forcing, and ERA5 atmospheric forcing



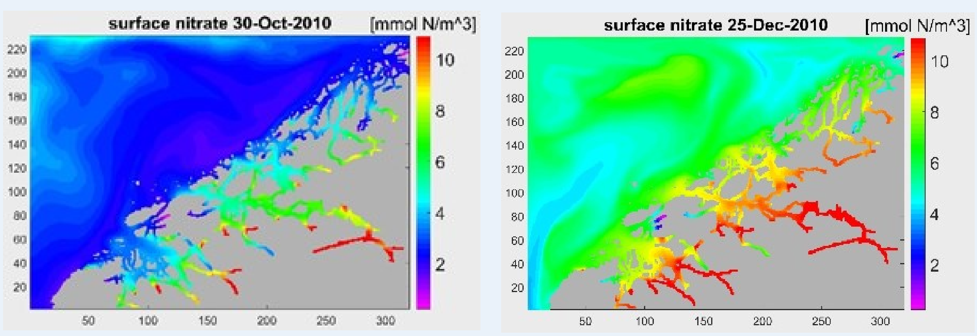
Preliminary Results

MED Sea

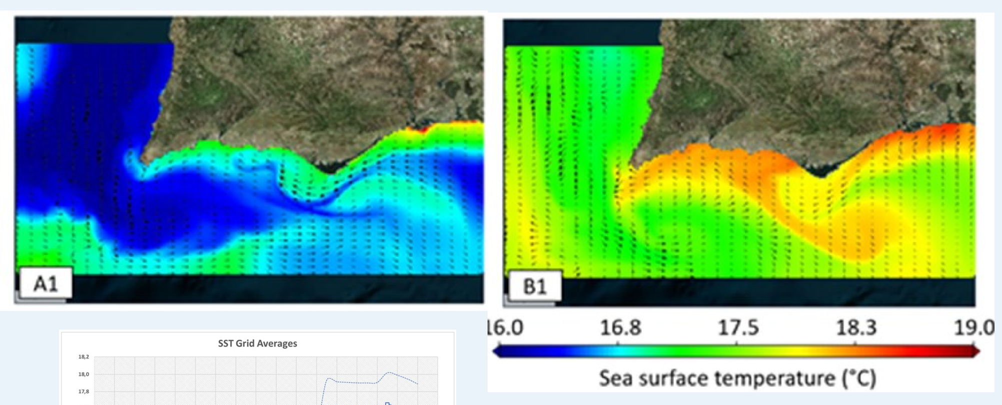


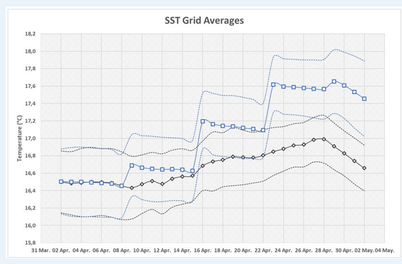
AVISO+ (2010-2014) season: 0=winter, 1=spring, 2=summer, 3=autumn

Hardanger Fjord



SW Iberia





A1: Upwelling Event (02/04/2021)
B1: Countercurrent Event (27/04/2021
Black line: FR; Blue Line: NR (April 2021)

Conclusions

The conceptual basis for the execution of OSSE in NAUTILOS are defined. The objective is to evaluate the impact of the new observation technologies on model accuracy and forecasting capabilities. Three study sites are addressed, with different dynamics, using different modelling suits, and addressing different processes. A common basis for the OSSE is defined where a high-resolution simulation of the system, the Nature Run (NR) is used to emulate the true state. Synthetic observations will then be extracted from this NR to emulate the real observations. Two sets of synthetic observations will be created, considering the Pre-Nautilos and Post-Nautilos situations. These take into consideration the number and location of the observations as well as their accuracy in both situations. Several assessing methods are proposed, which will enable a comprehensive evaluation of the model behavior. Preliminary model results are presented.

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Acknowledgments

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