Lake parameters climatology for cold start runs (lake initialization) in the ECMWF forecast system

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Coupling FLAKE to HTESSEL

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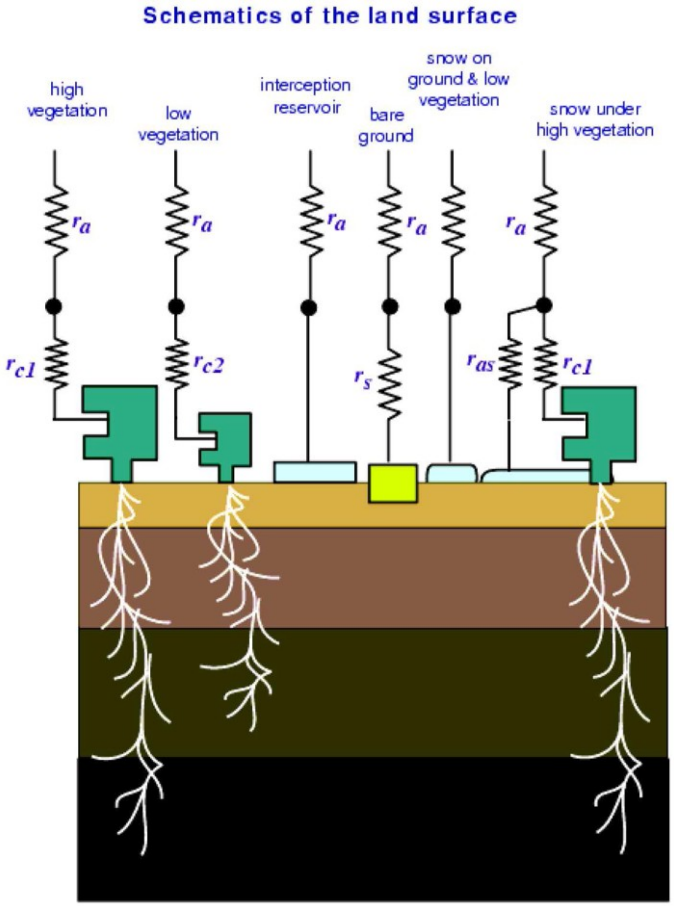

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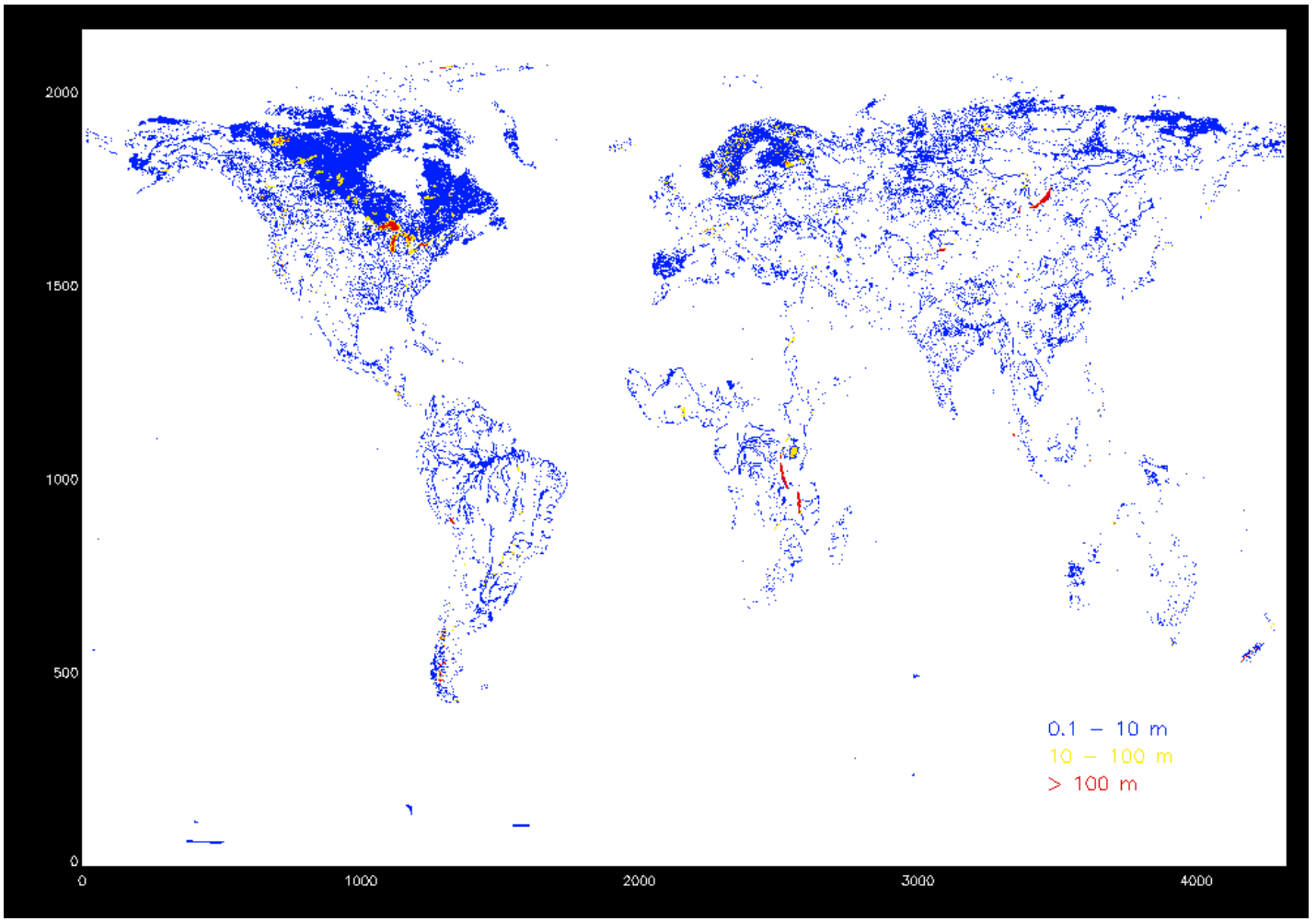
- **New TILE - allows sub-grid lakes**
- **Surface fluxes (heat moisture and momentum) from HTESSEL routines;**
- **No snow over frozen lakes !**
- **No bottom sediments !**
- **Surface characteristics (albedo, roughness, emissivity, etc) equal to water or sea ice tiles;**

Dutra EN, Stepanenko VM, Balsamo G, Viterbo P, Miranda PMA, Mironov D, Schaer C. 2010. Impact of lakes on the performance of global simulations with the ECMWF surface scheme, Boreal Environment Research

- The use of the FLake lake model inside an weather forecast system requires the knowledge of some parameters and the initial conditions of its variables.
- Parameters:
  - **Depth**
  - Extinction coefficient of solar radiation in water
  - Water surface radiative proprieties (albedos, emissivity)
- Lake variables are currently not treated by the data assimilation systems.
- One possible solution is to create a climate of FLake variables from off-line long periods simulations

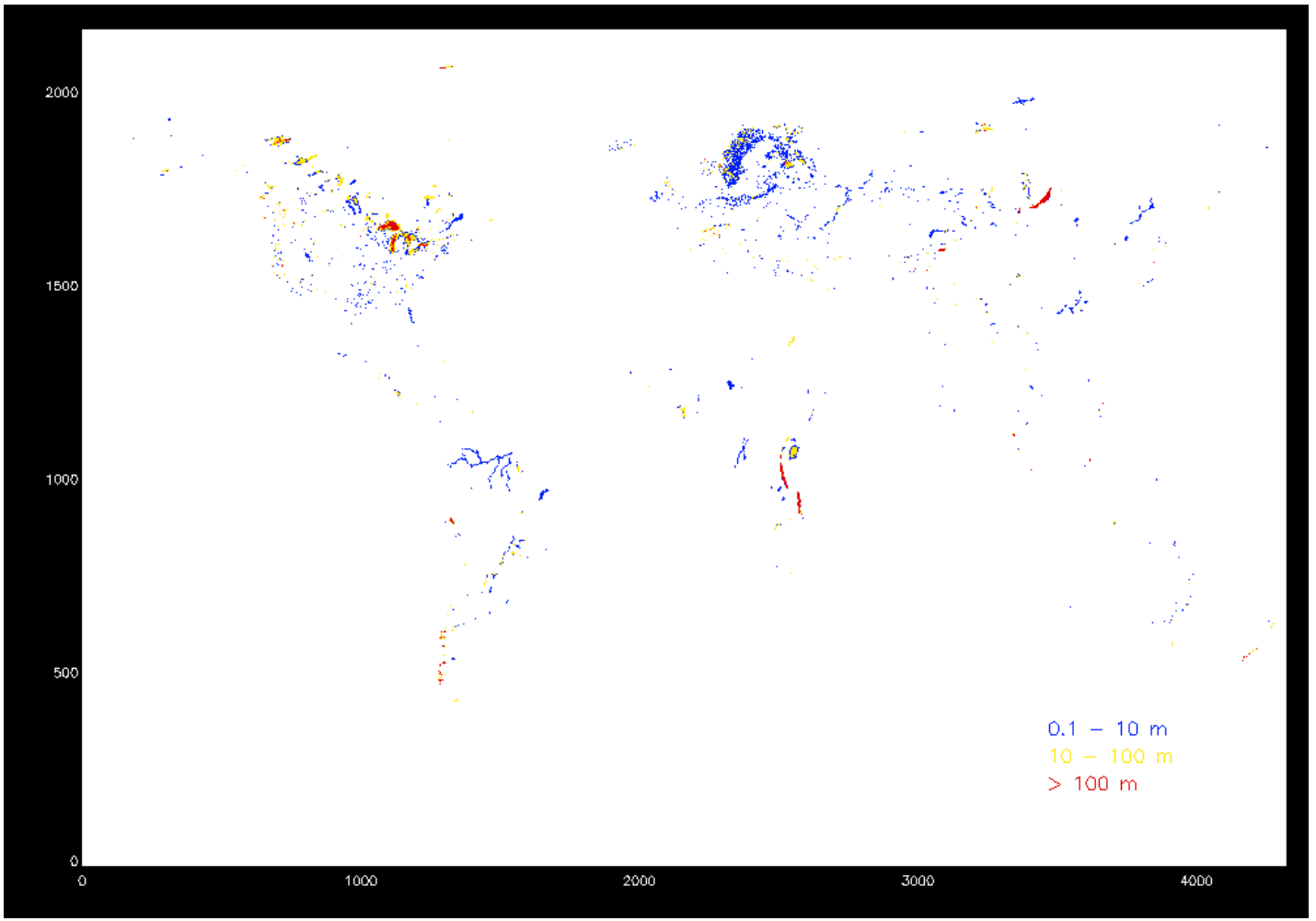
Global lake depth database

- Kourzeneva database
  - GlobalLakeDepth.dat
  - Resolution: 30 sec. of arc.



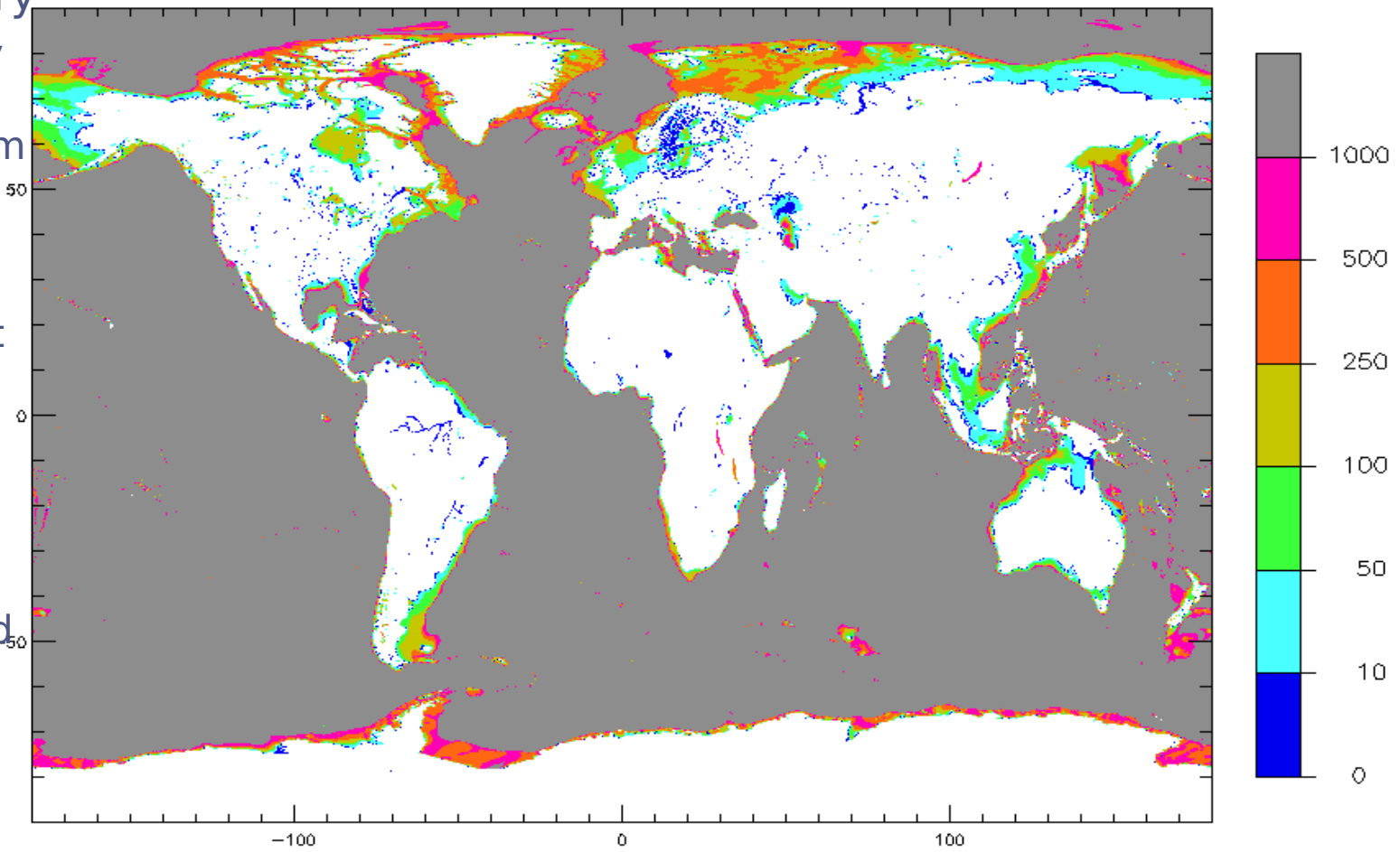
Global lake depth database

- Only where there are real information about lake depth



Global lake + Caspian + Ocean depth database

- Kourzeneva database
  + Caspian bathymetry
  + Ocean Bathymetry
  - Ocean bathymetry from ETOPO at ~2km resolution
  - Caspian bathymetry at ~4km resolution
  - Default: 30 m
  - Minimum: 1m
  - Resolution: aggregated to 5 arc min



How to obtain initial values for cold starts?

- Flake (water + Ice) variables (7, 6 independent)
  - Surface or mixed layer temperature
  - Bottom temperature,
  - Mixed layer depth
  - Shape factor
  - Mean water temperature
  - Ice depth
  - Ice temperature

LAKE PLANET *experiment*

- Long Off-line simulation with HTESSEL+FLake
- Forcing: ERA-Interim reanalysis
  - 1989 – 2009 (21 Years)
  - 3 hourly atmospheric input data
  - N128 resolution (~80km)
- Lakes overall (lake fraction = 1 over all grid points) with:
  - Constant depth (30m)
  - **Variable depth (Kourzeneva + Caspian + 100m ocean + 30 m default)**
    - ***Grid box depth is aggregated from lake depths at higher resolution.***
- Spin-up: 10 years with 1989 forcing

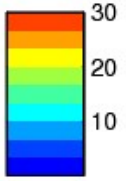
LAKE PLANET Validation

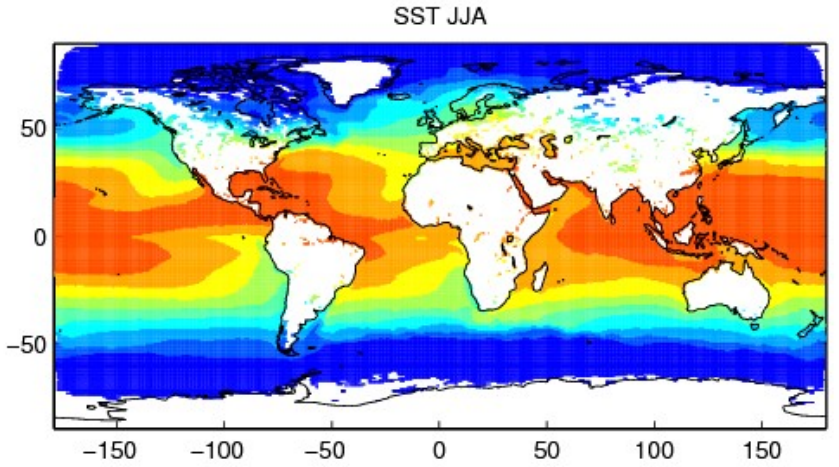
In order to validate we are using the following available information

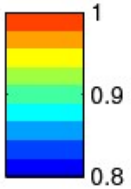
- Lake Surface Temperature
  - MODIS SST
- Ice
  - IMS (Ice Mapping System), sea-ice product from NOAA
  - Global Lake and River Ice Phenology Database (from NSDC)
    - *ice cover descriptive data for 750 lakes*
- Lake thermal structure (Flake variables)
  - Local scale available data

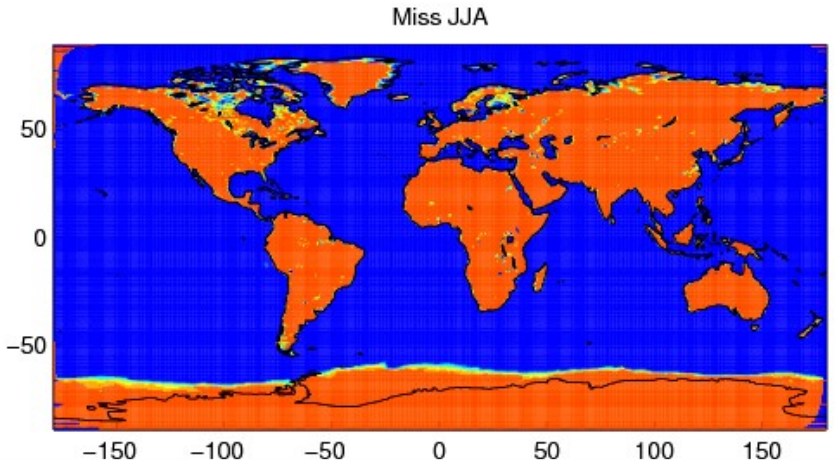
MODIS SST

- Available from 2001 (up to 2009)
- Resolution: 4 km
  - Aggregated to the N128 gaussian grid
- Daily database (nighttime and daytime)
  - 8 Day mean SST (DSST+NSST) were used
- Includes information about percent o missing values
  - Only points with less than 80% missing values were considered





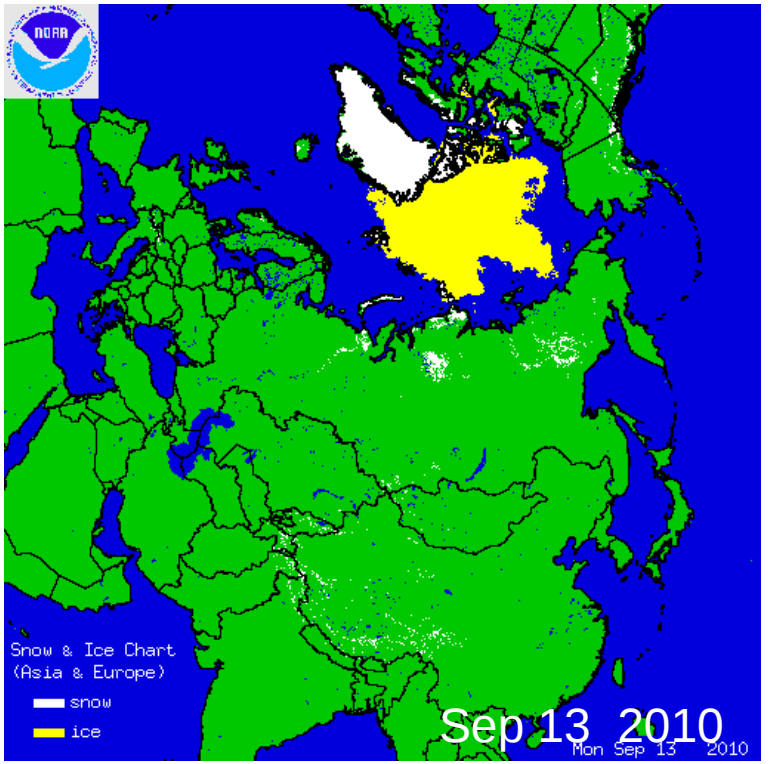




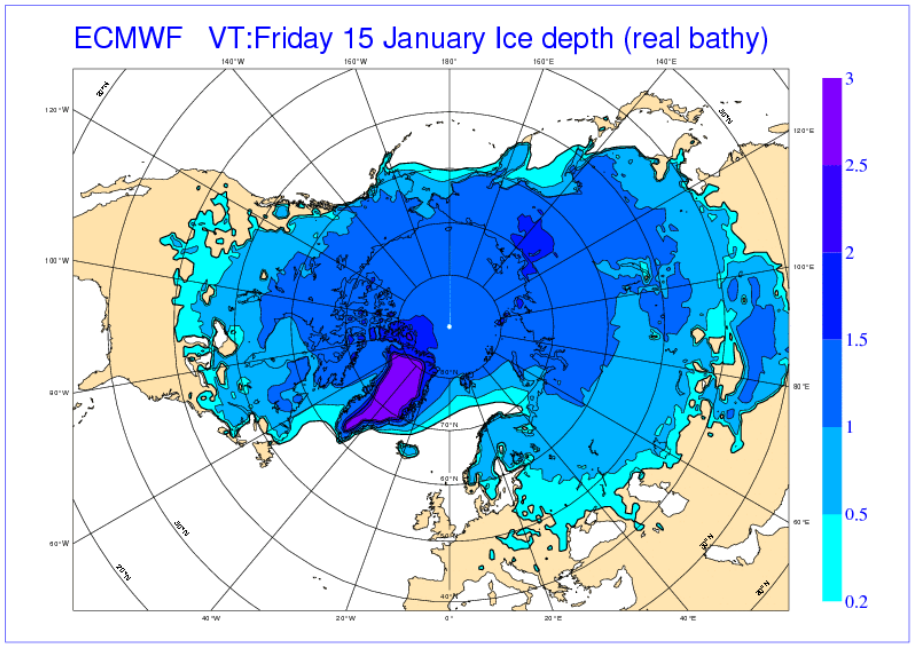
Summer mean SST and missing values

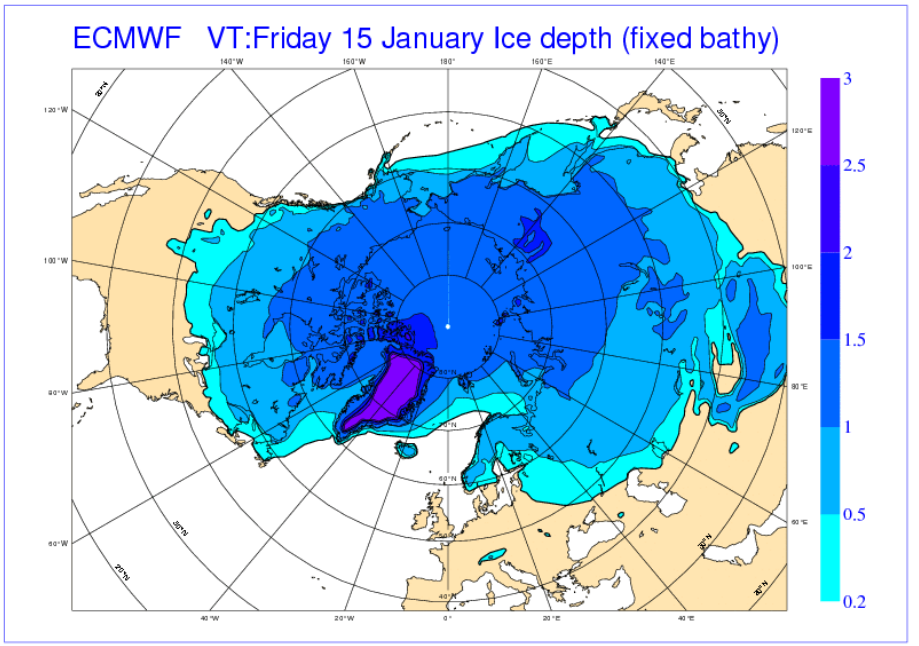
NOAA IMS sea-ice

- Available since 1998 at 25km (at 4km from 2004)
  - Only Northern Hemisphere
- Daily database of the ice cover (yes or no for each pixel)
- For each year and IMS pixel we compute:
  - lake ice formation date
  - breakup date
  - Ice season duration (days)
- Aggregated to the N128 gaussian grid

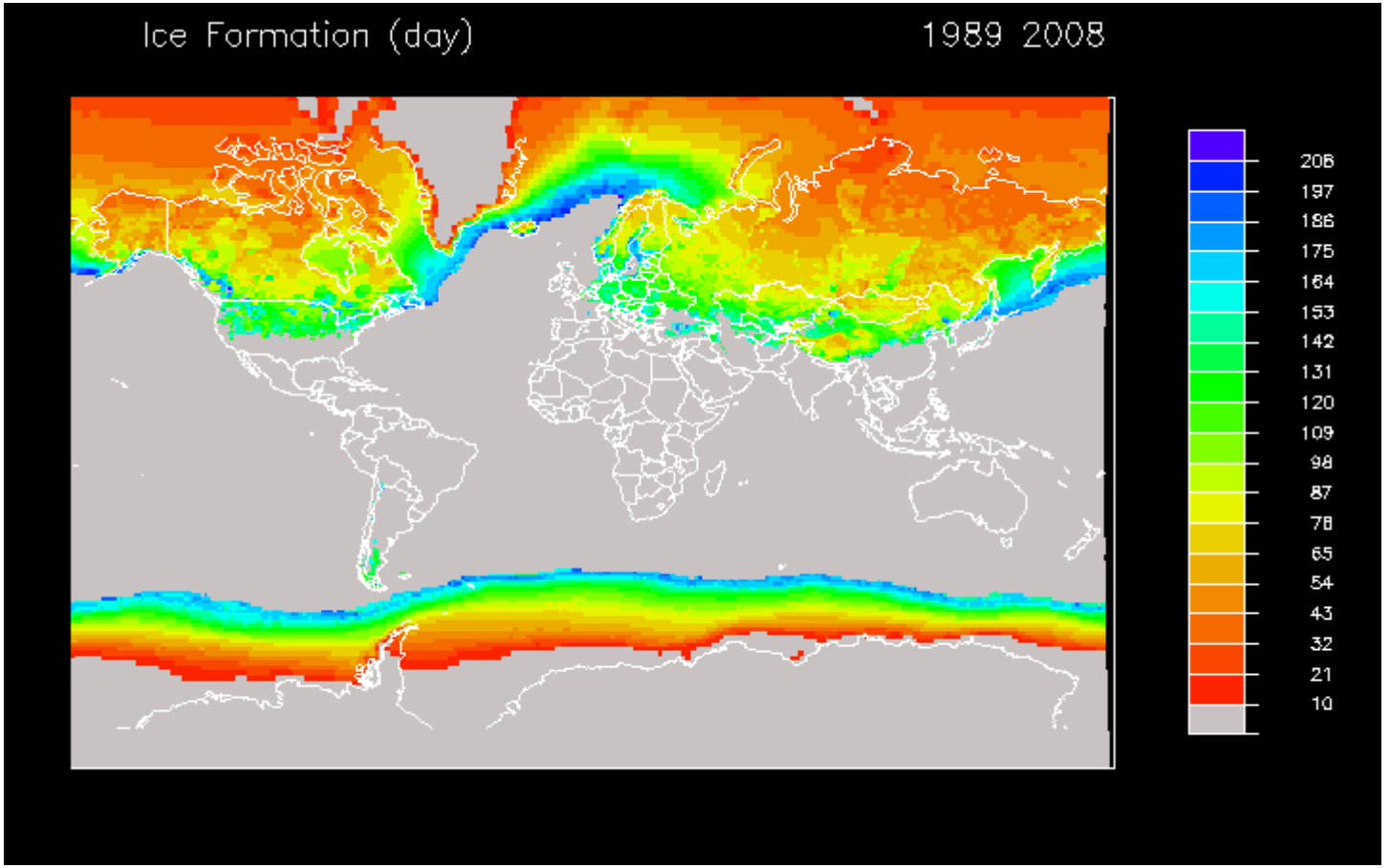


Lake Planet results – Ice Depth

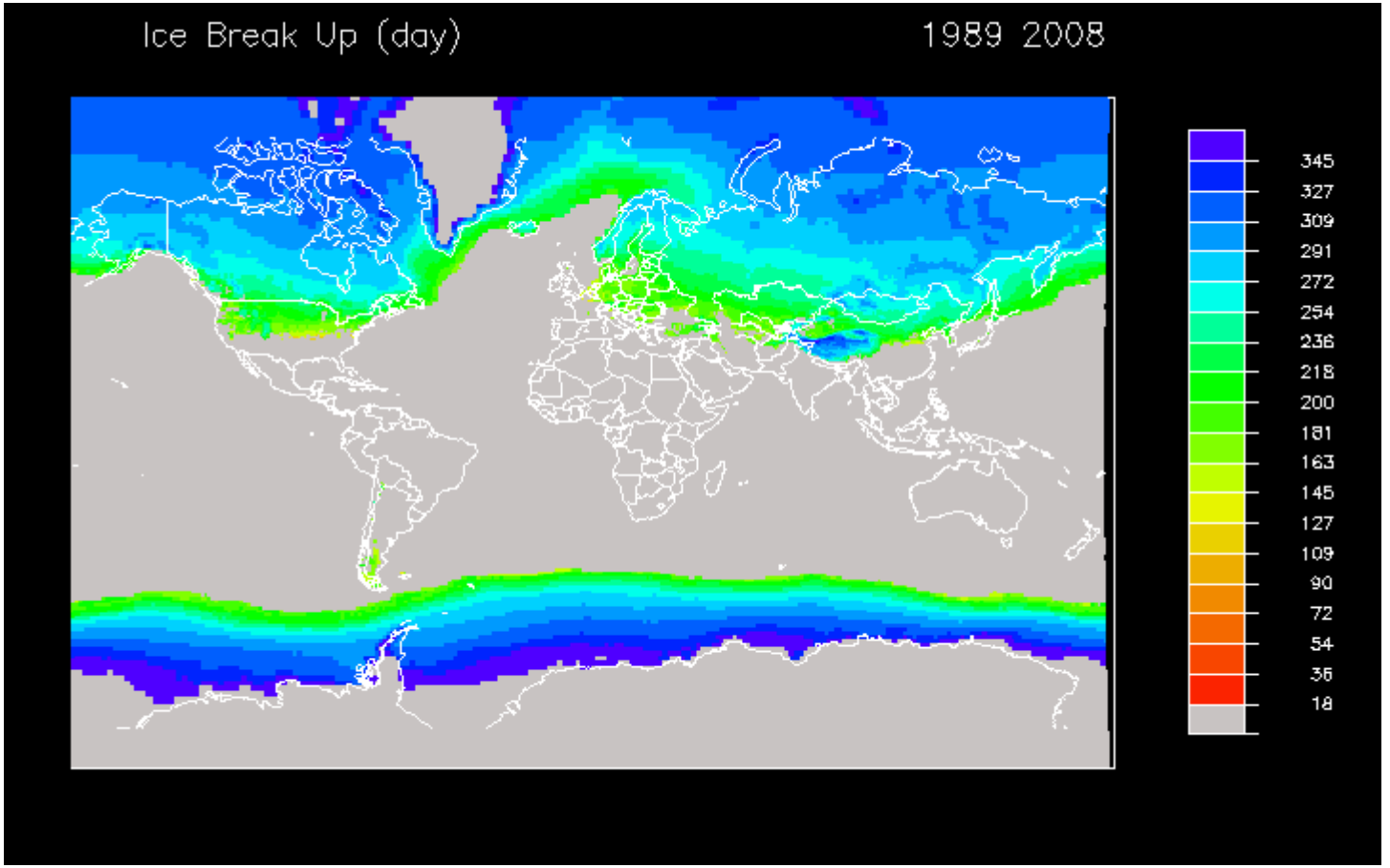




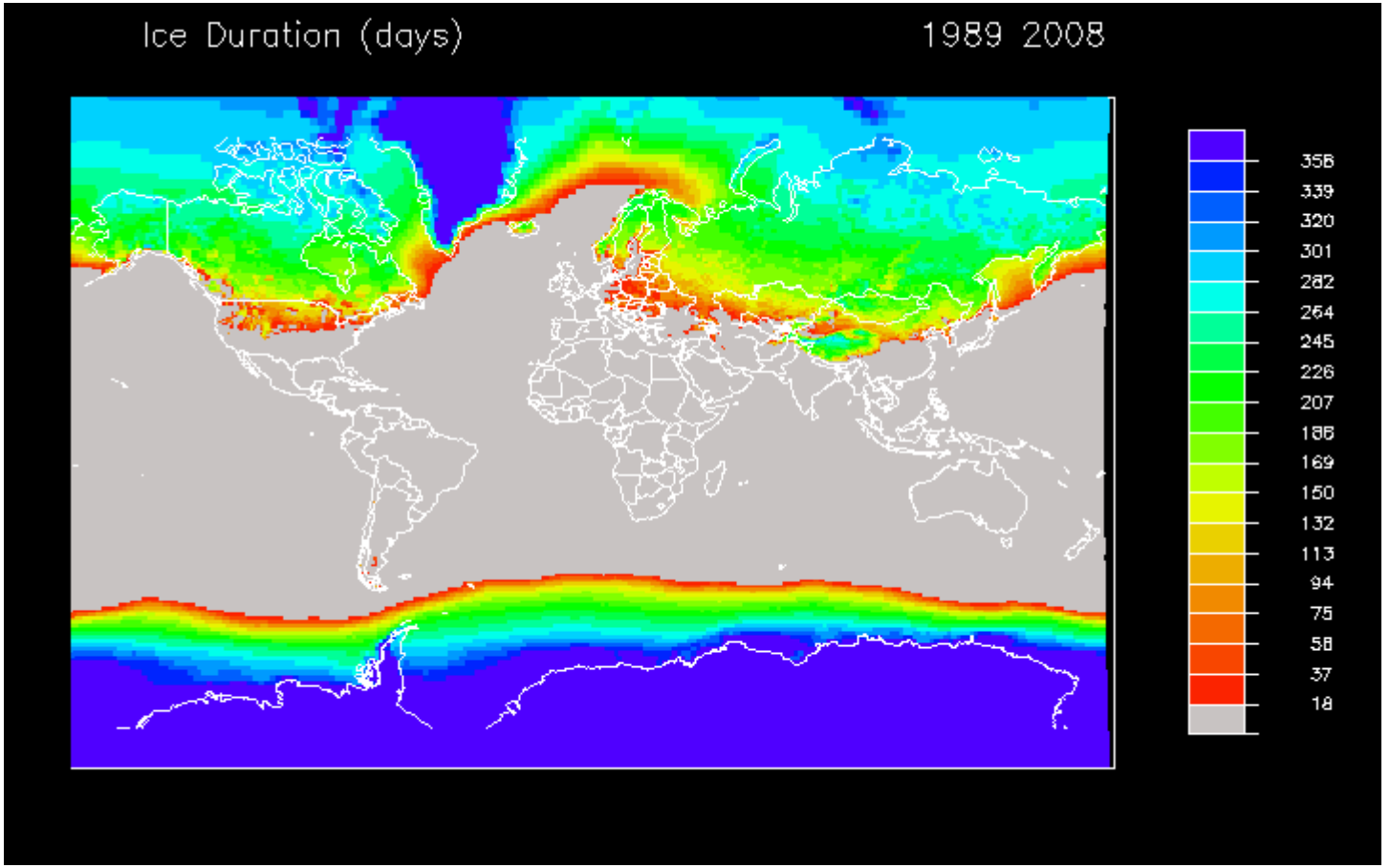
Frozen day


Ice Formation (day)
1989 2008
208
197
186
175
164
153
142
131
120
109
98
87
76
65
54
43
32
21
10

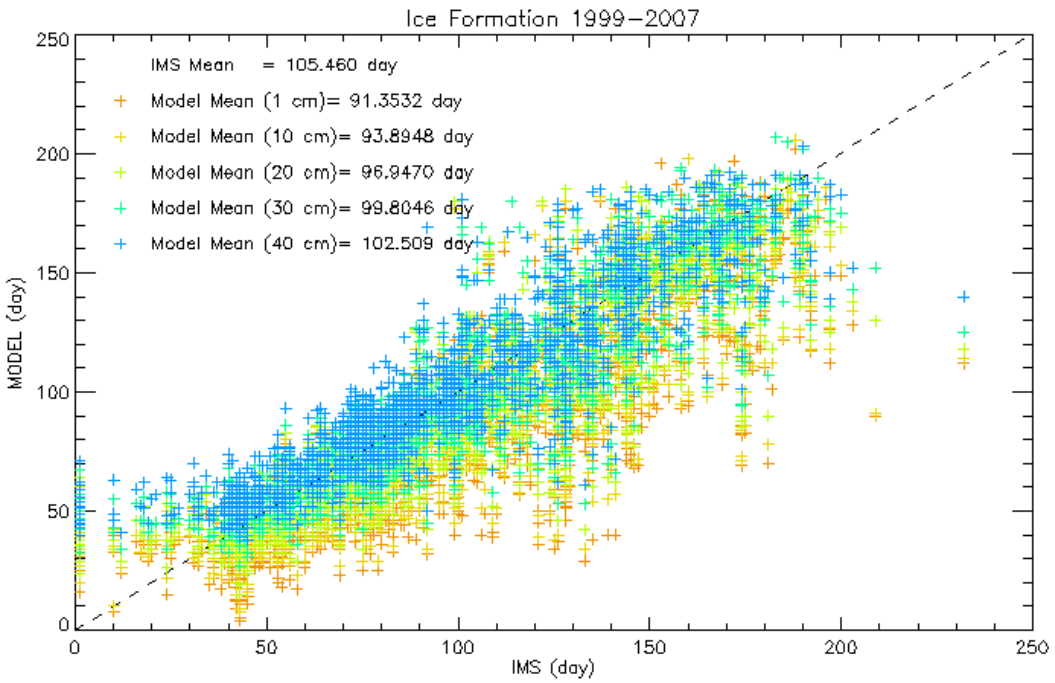
Ice Break up

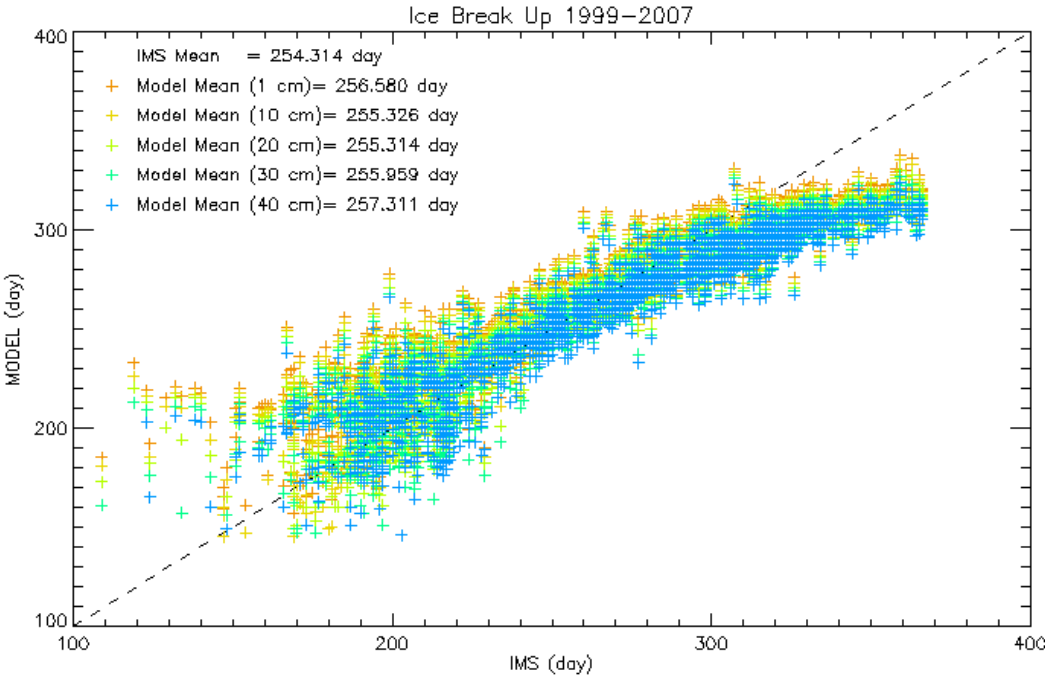

Ice Break Up (day)
1989 2008
345
327
309
291
272
254
236
218
200
181
163
145
127
109
90
72
54
36
18

Lake Planet – Ice duration



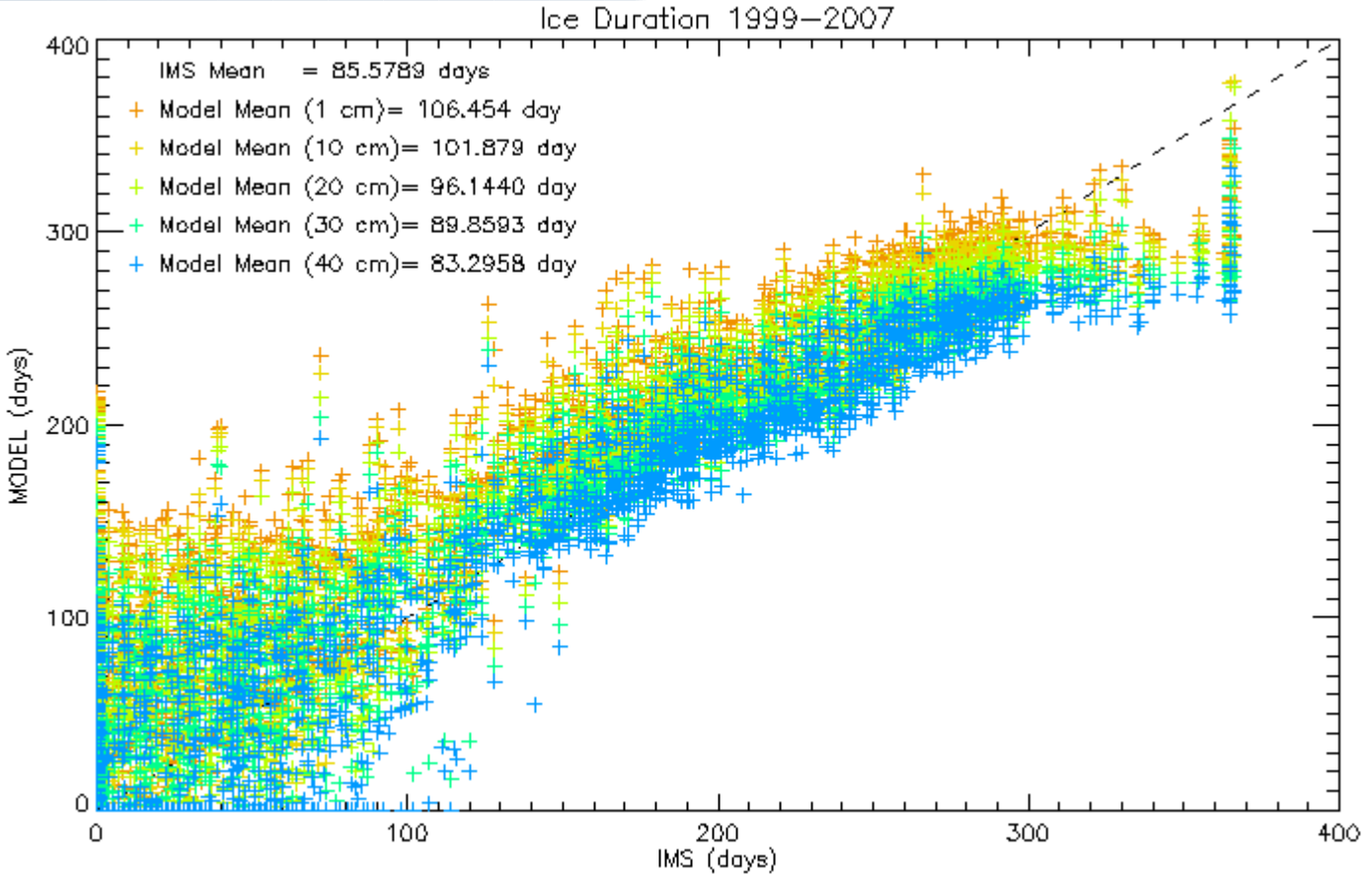
Lake Planet validation – ICE formation and break - up



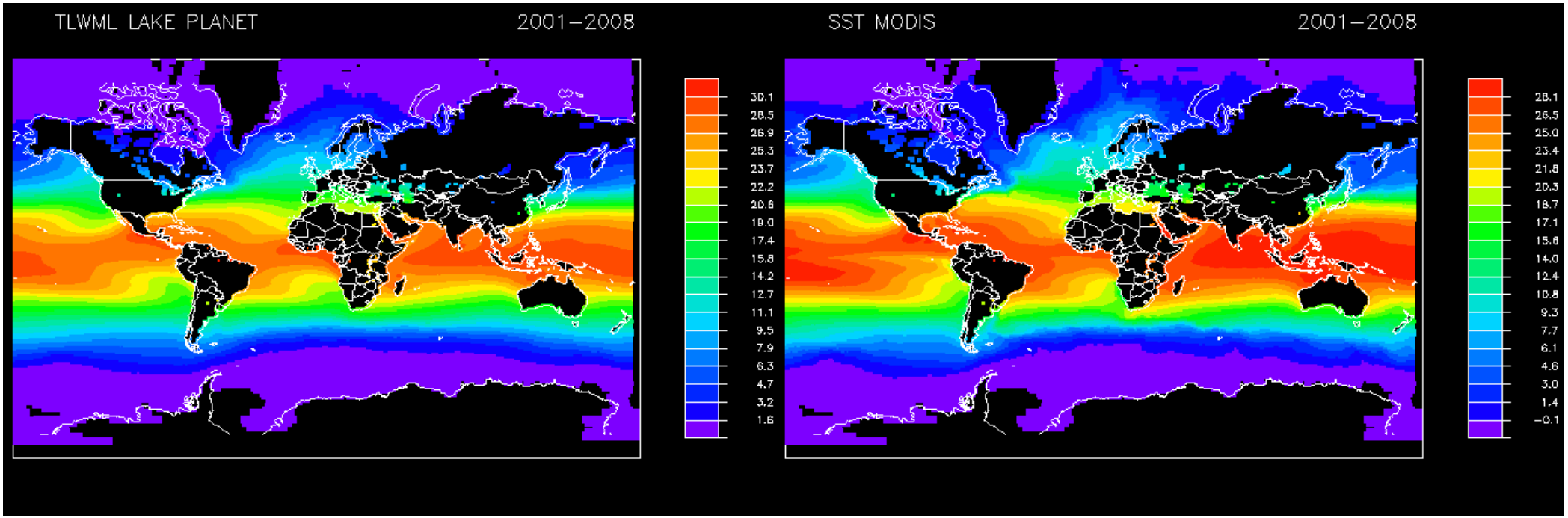


The model tends to freeze sooner – about 10 days before in averaged
The break-up is well simulates
At high latitudes, modelled Ice breaks up (or breaks up earlier)

Lake Planet validation – ICE duration



Lake Planet validation - SST



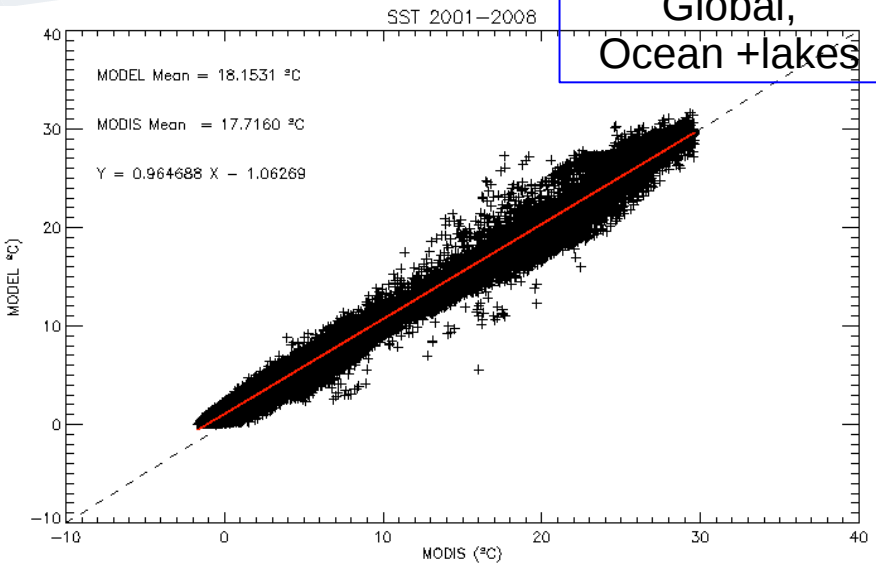
Mean Surface Water temperature – Lake Planet experiment and SST from MODIS (includes inland points - LST)

SST LakePlanet versus MODIS

RSME (Total) = 2.1 ºC
RSME (lakes) = 5.5ºC

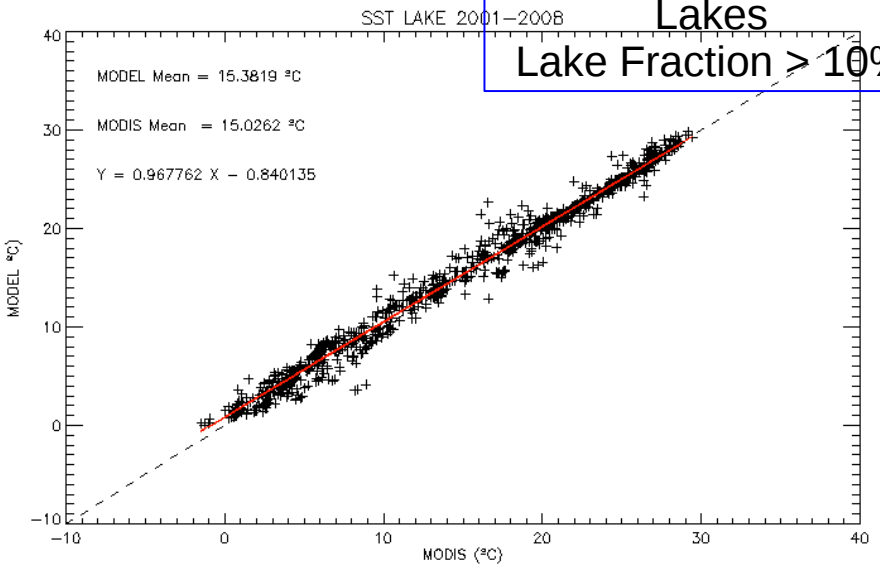
BIAS (total) = 0.4
BIAS (lakes) = 0.7

Global,
Ocean +lakes

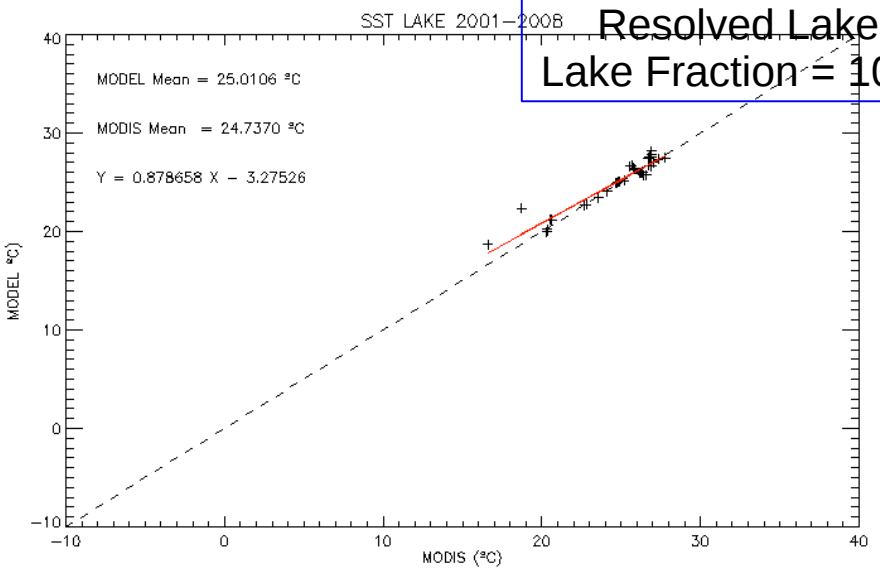


Temporal mean SST
Good agreement

Lakes
Lake Fraction > 10%



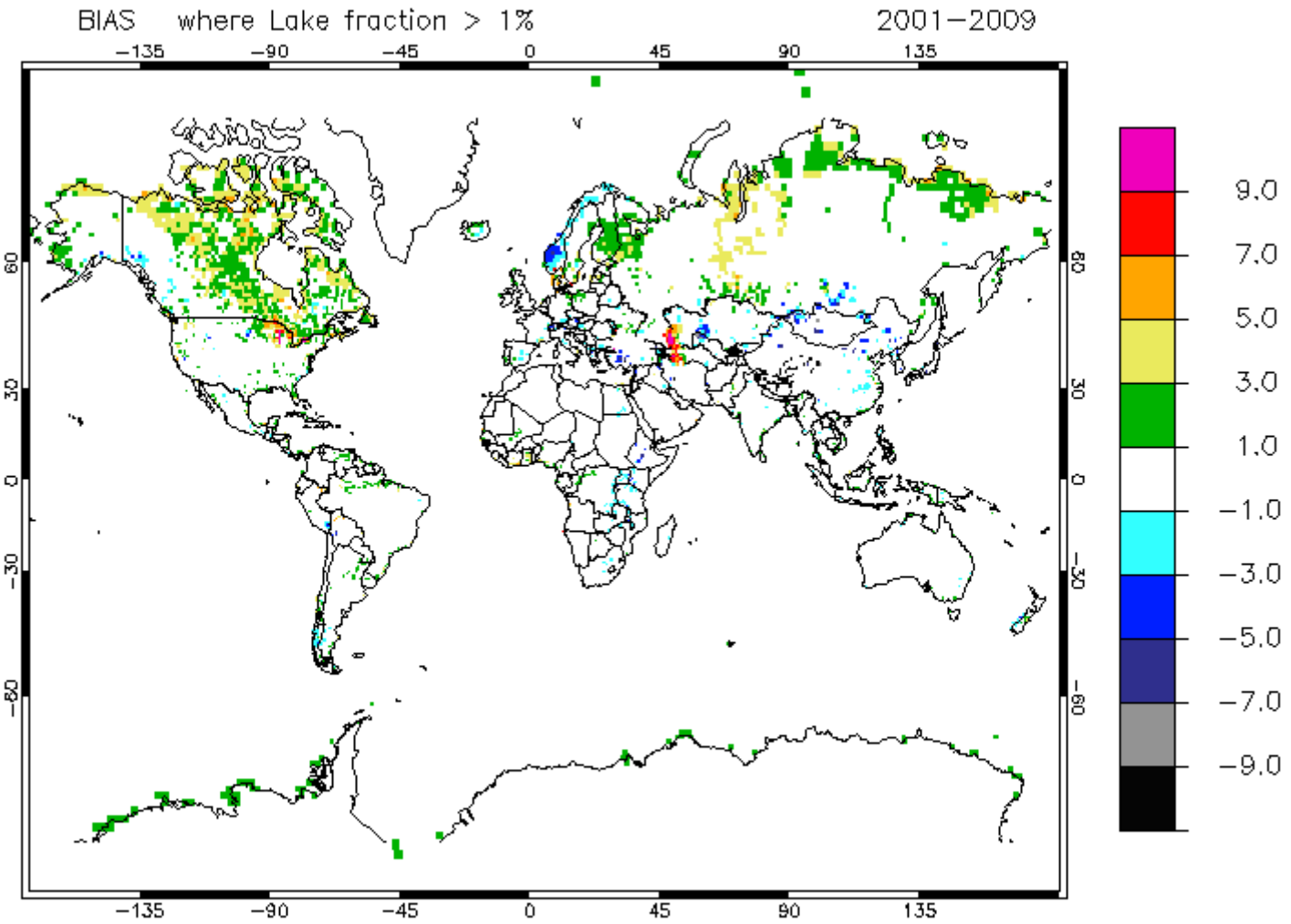
Resolved Lakes
Lake Fraction = 100%



SST LakePlanet versus MODIS (BIAS)

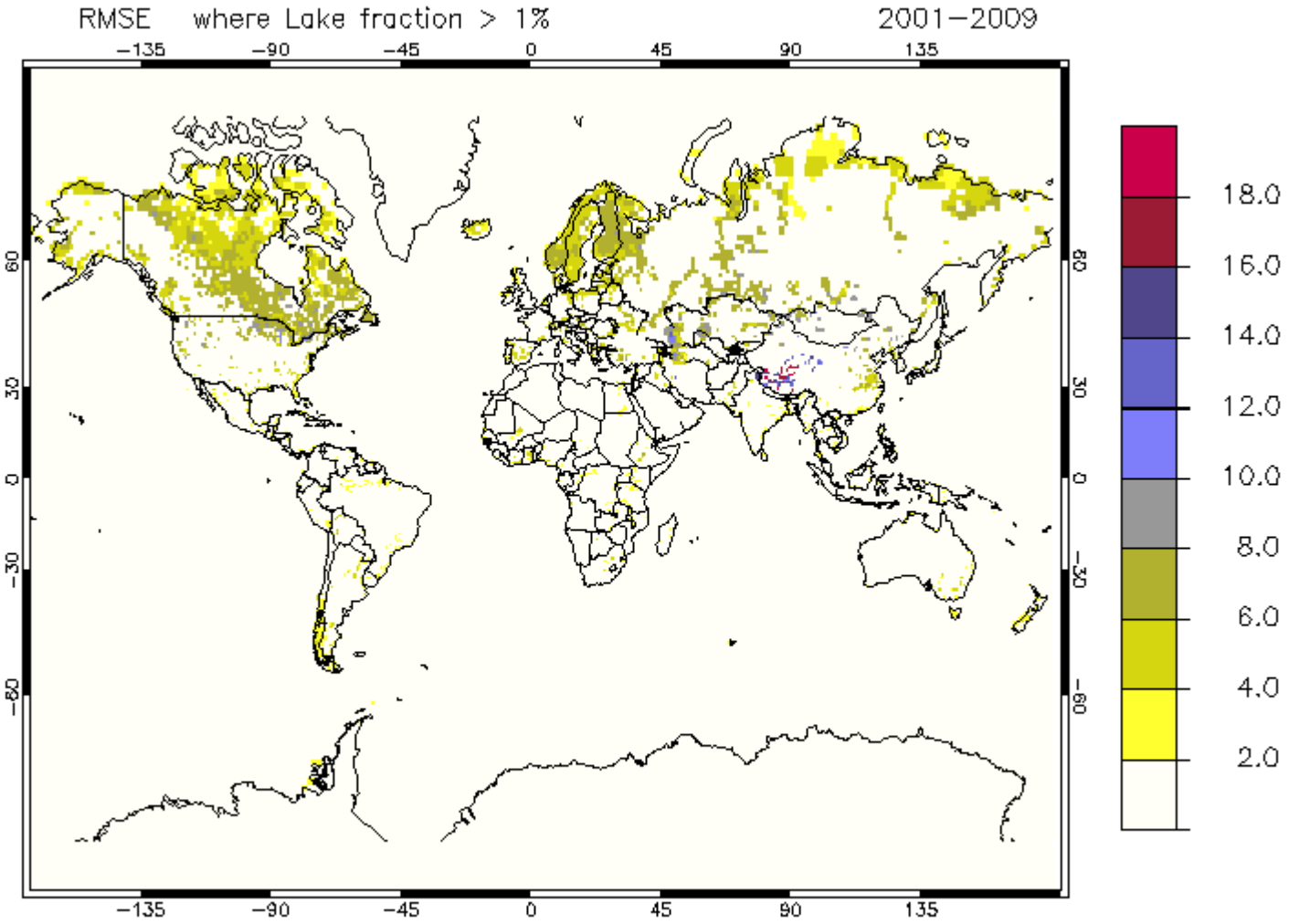
Positive bias:
Great lakes
Caspian
Mean latitudes

Negative bias:
Scandinavia
Victoria

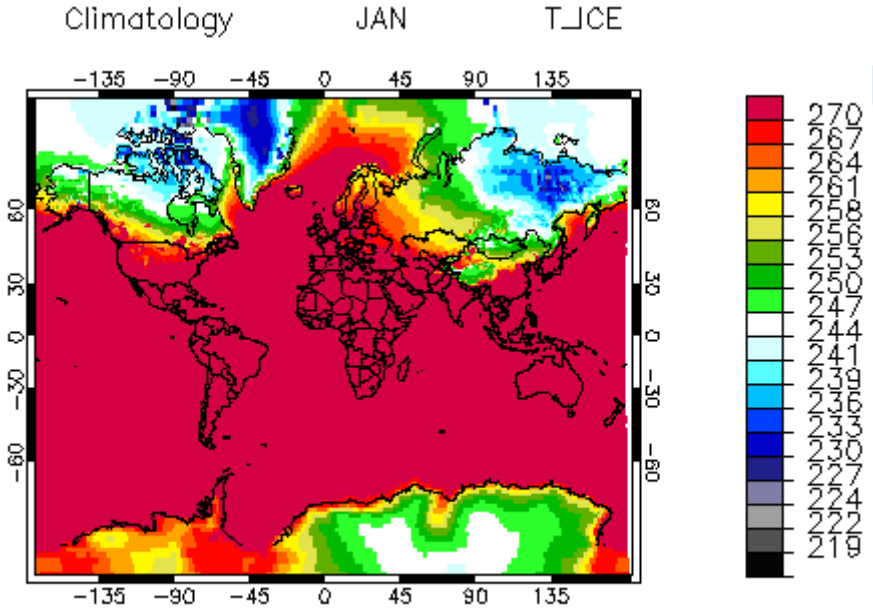


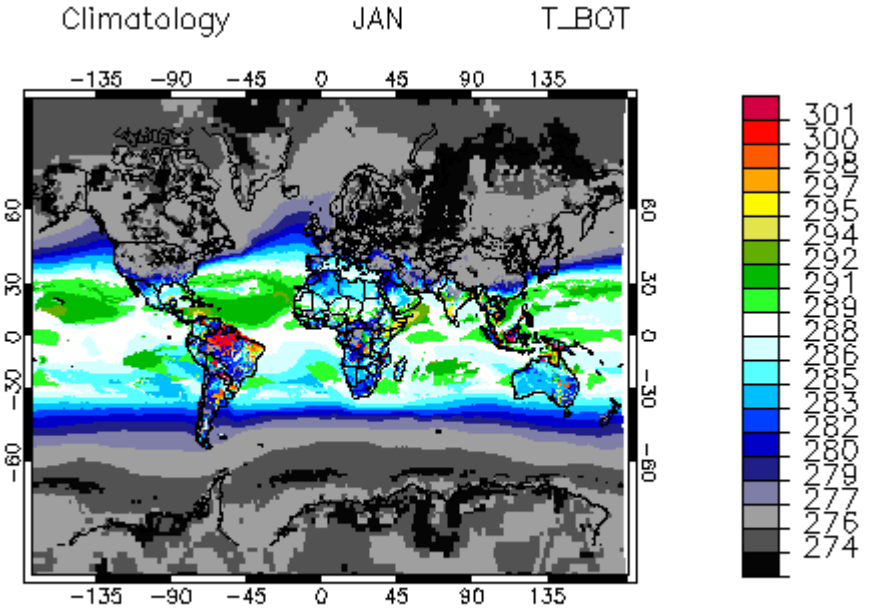
SST LakePlanet versus MODIS (RMSE)

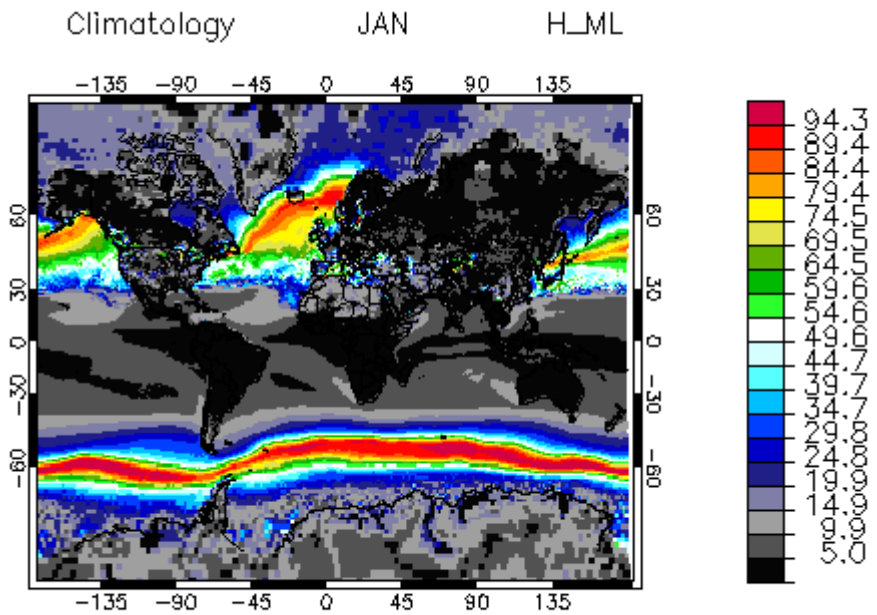
High RSMEs Over
- Caspian
- Southern Great Lakes
- *Himalayas region*

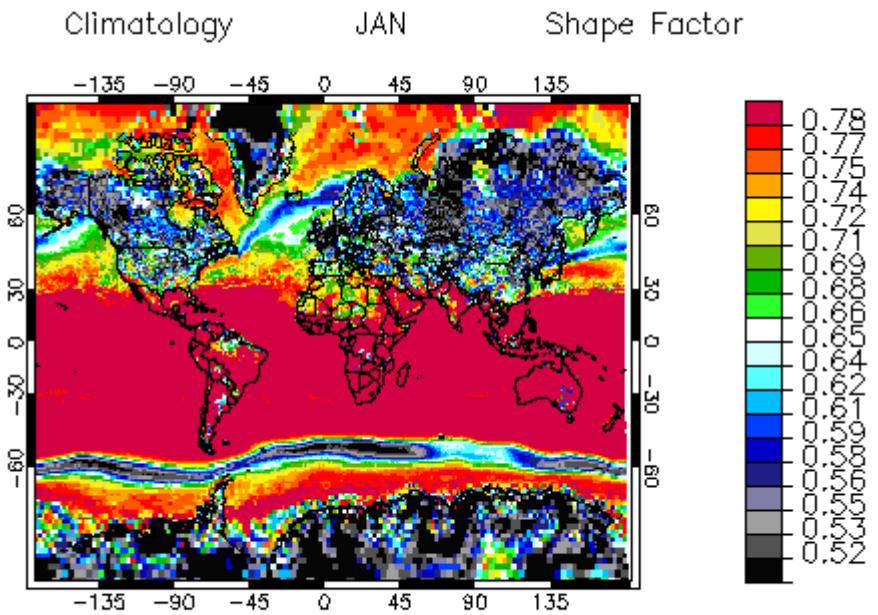


Lake Planet Climatology (Example: January)









Conclusions

- A monthly climatology of FLake variables has been created
  - For IFS cold start runs – may be interpolated for different grids
  - Based on a LAKE PLANET experiment forced by ERA Interim Re-analysis (1998-2009)
- The validation of the LAKE PLANET is ongoing. Preliminary results shows:
  - Ice begins sooner in the experiment; Ice break-up is, in averaged, better simulated
    - *ICE Break-up in Arctic Summer (initialization, and fresh - water)*
  - High Bias and RSME over Caspian water surface temperature
    - *The use of analysed SST will be better*
  - Other Flake variables have to be validated
    - *The Lake Model Intercomparison Project?*
    - *Some values seems to be not physically consistent*