Special Bureau for Loading:
Potential Role Versus Reality

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Special Bureau for Loading:
Potential Role Versus Reality

- What could be the role of a SBL?
- What is the current SBL?
- Status of work?
- Urgent steps
- Long-term vision

What could be the role of a SBL?

Provide an operational (digital model) movie of the dynamic Earth, featuring

- **temporal development of the Earth's shape,**
- **temporal variation of gravity field,**
- **temporal variations of rotation,**

as determined for *An Global Integrated Model of Surface Loads on the Earth* (AGILE).

Support an extended Reference Frame definition (non-linear reference coordinates model).

Make available a model of the global mass movement in the fluid envelope of the Earth consistent with geodetic observations.

What could be the role of a SBL?

What is necessary in order to acquire this role?

- **considerable participation of the community;**
- **support from the other SBs;**
- **combination of the three pillars of geodesy;**
- **Earth system model;**
- **data assimilation (for the mass model).**

What is the current SBL?

- Formally established on 1 February 2002;
- Initially 10 members plus the chairs of the other SBs as ex officio members, chair: Tonie van Dam;
- First workshop in March 2002 in Luxemburg: number of recommendations;
- SBL web page at http://www.sbl.statkart.no since 2002;
- Research products: loading time series for all network stations, frequently updated, different input data, Earth models, and computational approaches;
- Operational products based on ECMWF low-latency products;
- Since 2004: Chair: Hans-Peter Plag
- Two additional projects: PGR-FPG and AGILE.

Status of Work

Web Page:

Main Page:

- Web Site Map
- News
- About the SBL
- Products
- About loading
- Meetings
- Projects of the SBL
- Literature relevant to loading
- External Links
- Archive

Products

- Products for research
- Operational products
- Regression coefficients
- Links to external load data
- Auxiliary products (data and tools)

Projects of the SBL

- Post-glacial rebound (PGR-FPG)
- Surface mass model (AGILE)

Maintained by Norwegian Mapping Authority:

- Web server with 1 Tbyte disk
- Annual fees for access to low latency data
- Staff for operational computations (Halfdan Kierulf)
- http://www.sbl.statkart.no

Status of Work

PROJECTS:

AGILE: A Global Integrated Surface Load Model for the Earth

- Mainly conceptual work so far
- Reservoir data from Ben Chao
- Inventory of potential data sources

PGR-FPG: Predictions of Present-Day PGR Finger-Prints in Geodetic Quantities

- Goal:
  - quantify the uncertainties in present-day PGR model predictions,
  - study whether a community-accepted mean model can be determined.
- Call for submission issued in 2004
- A total of five predictions submitted by three groups
- Many others reluctant to submit predictions
- General consensus: There is no community model, no best estimate.

Status of Work

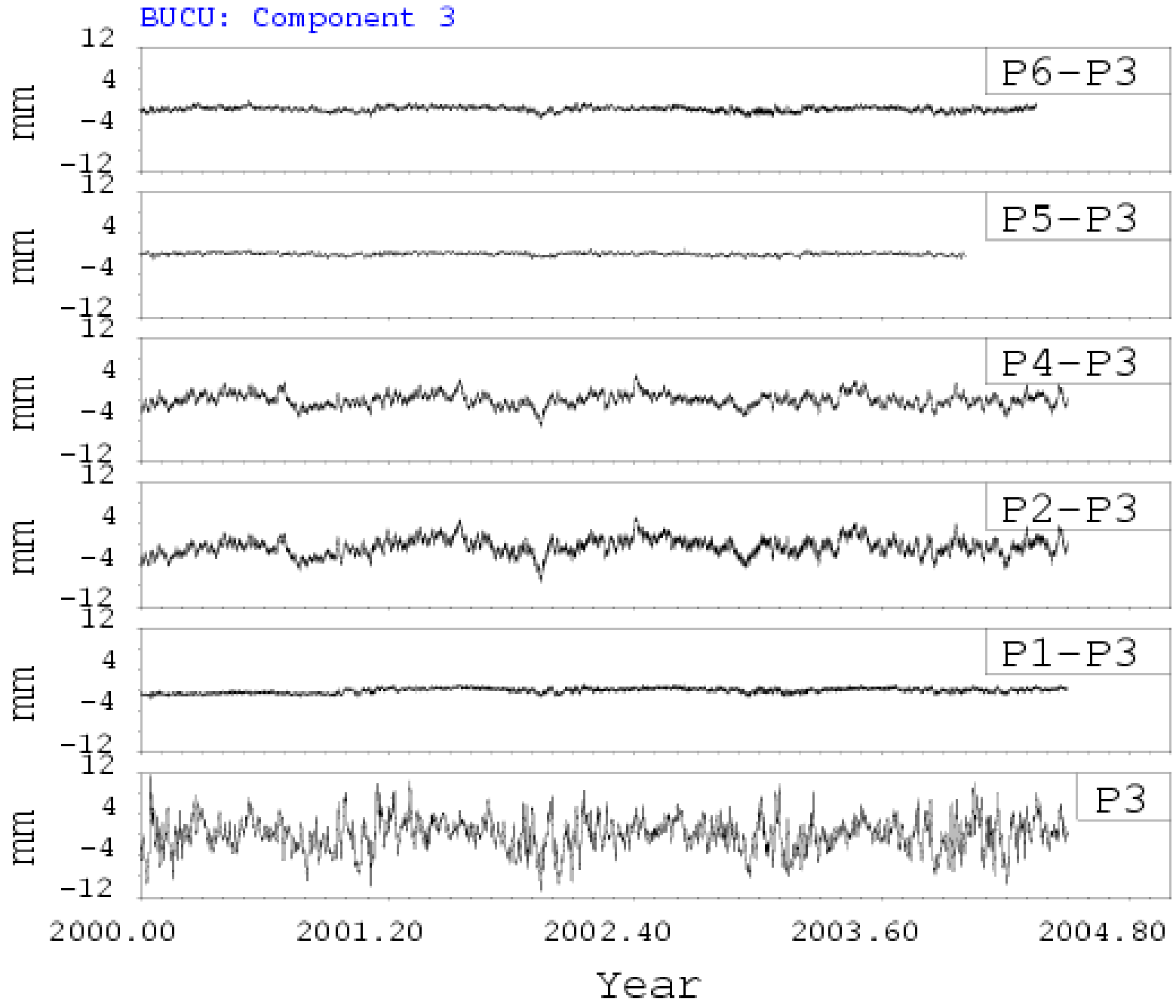
Research Products:

- **Several different predictions of air pressure loading-induced displacements**

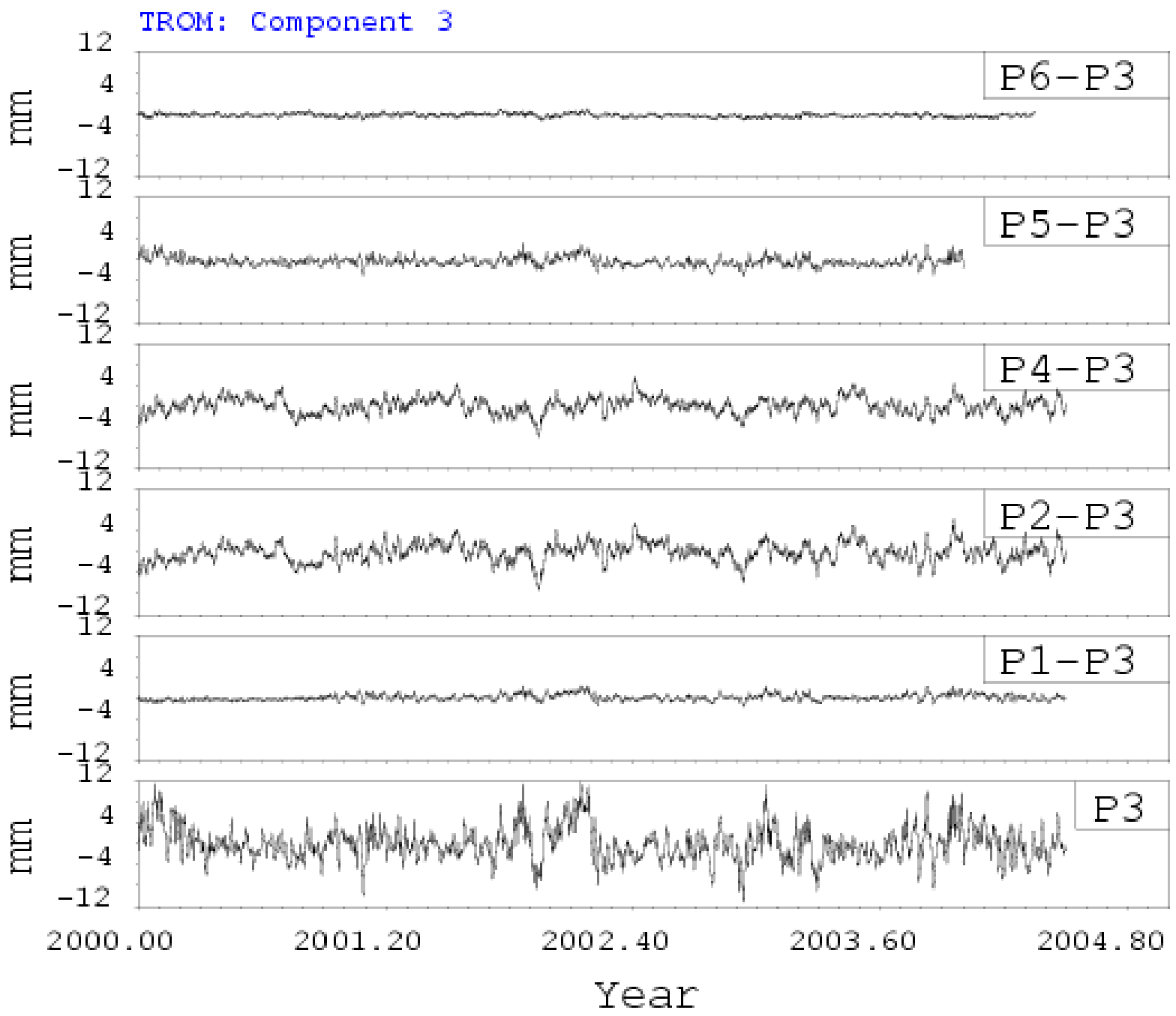
Pr.	Input	R.F.	E.M.	Co.	A.
P1	ECWMF	CE	PREM	SHE	PG
P2	ECWMF	CM	PREM	SHE	PG
P3	NCEP	CE	PREM	SHE	PG
P4	NCEP	CM	PREM	SHE	PG
P5	NCEP	CE	G+B	CGF	TvD
P6	ECMWF	CE	G+B	CGF	HPK

- Air pressure sources: European Center for Medium Range Weather Forecast (ECMWF) and National Center for Environmental Prediction (NCEP).
- Origin of the reference frames (R.F.): Center of mass of the solid Earth (CE) and Center of mass of the whole Earth system (CM)
- Earth models (E.M.): PREM and G+B (Gutenberg - Bullen).
- Computation methods (Co.): SHE: Summation of spherical Harmonic Expansion; CGF: Convolution of Green's Function and load anomaly.
- Authors (A.): PG: Pascal Gegout; TvD: Tonie van Dam; HPK: Halfdan P. Kierulf.

Status of Work



Status of Work



Status of Work

Current situation:

- Intercomparison overoptimistic (computations too similar)
- Error budget not fully understood;
- Quantitative study in progress.

Contribution	Bias	Std	Maximum	Comment
Air pressure anomaly				
Air pressure data				
Earth topography				
Computation of the air pressure at topographic height				
Air pressure reference surface				
Ocean response to air pressure and wind forcing				
Ocean function				
Wind forcing				
Deviations of ocean response from inverted barometer				
Loading calculation				
Contribution of the Earth model				
Computation of Love numbers/Green's function				
Convolution				
Other contributions				
NN				

Status of Work

Operational products:

Available with:

- low latency (approximately 17 hours)
- temporal resolution: 6 hours
- spatial resolution: 2.5 x 2.5 degrees

Status of Work

Operational products:

Required: $p(x,h_T,t)$-$p_0(x,h_T)$

Several possible ways to get $p(x,h_T,t)$ from model output:

P1:

- Grided pressure and temperature at mean sea level are interpolated spatially, propagated to topographic height with approximate solution of the hydrostatic equation.
- Error due to spatial interpolation is small.
- Computation load: small.
- Data requirements: restricted to the pressure and temperature field at MSL.
- Accuracy: low since both temperature and air pressure at MSL are extrapolated from the respective fields at orographic height.

Status of Work

Operational products:

Required: $p(x,h,t)$

Several possible ways to get $p(x,h,t)$ from model output:

P2:

- Spherical harmonic expansions of p and T at model orography h_M are evaluated with the required spatial resolution and then propagated from h_M to h_T.
- Computational load is high (many evaluations of the spherical harmonic expansions
- Data requirements: pressure and temperature fields at orographic heights.
- Accuracy: high, because difference between model orography and topography small almost everywhere.
- Consistency: high since all required fields are modeled quantities.

Recommended by ECMWF!

Status of Work

Operational products:

Required: $p(x,h,t)$

Several possible ways to get $p(x,h,t)$ from model output:

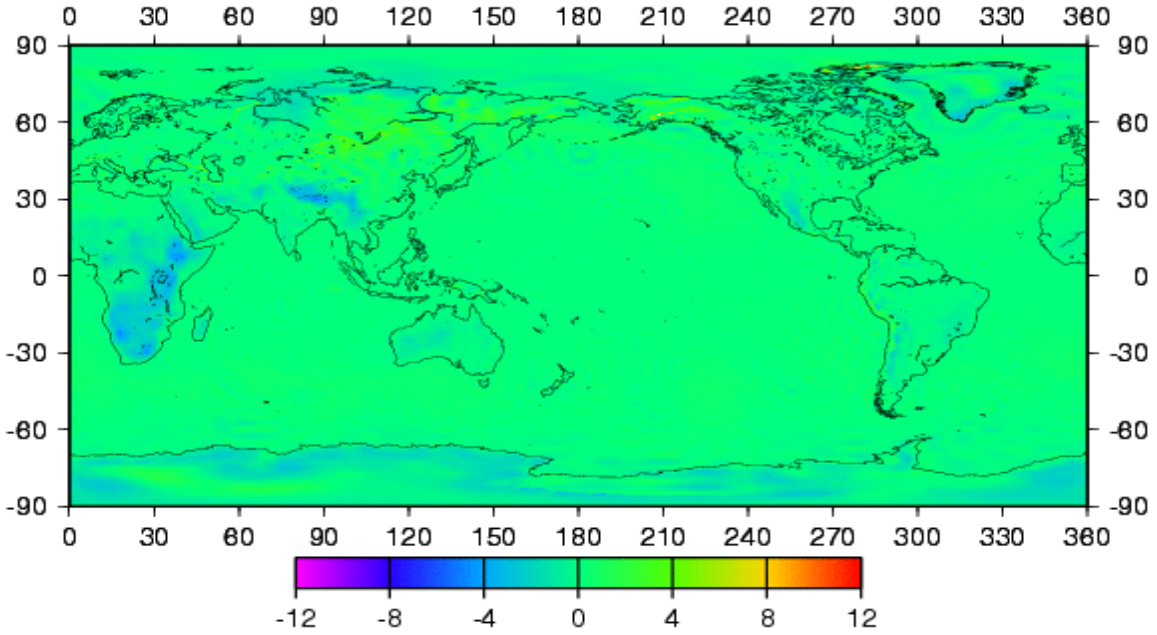
P3:

- Spatial interpolation of a number of geopotential heights to position x, computation of $p(x,h_T)$ through interpolation over height.
- Requires geopotential fields for up to ten pressure levels and two interpolations (first to the spatial point and then in height).
- Computational load comparable to P1
- Accuracy depends on the accuracy of the geopotential height and interpolation algorithm.

Currently P1 and P3 implemented.

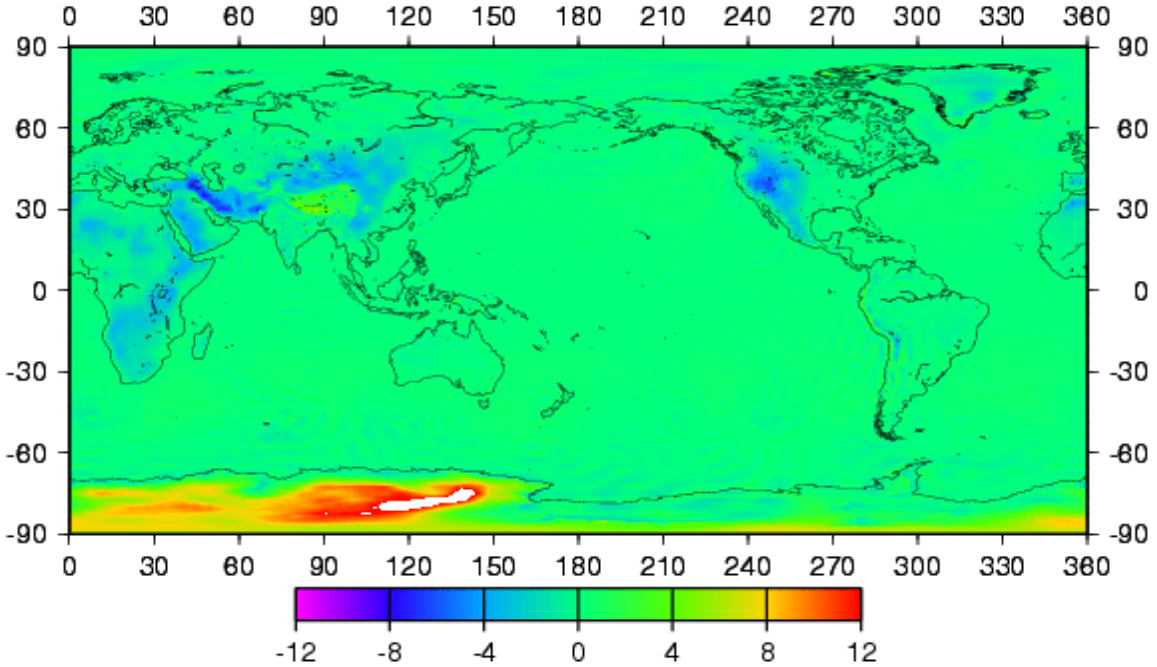
Operational products still P1.

Status of Work



Differences between P1 and P3 (ERA40)

2000-01-01-12



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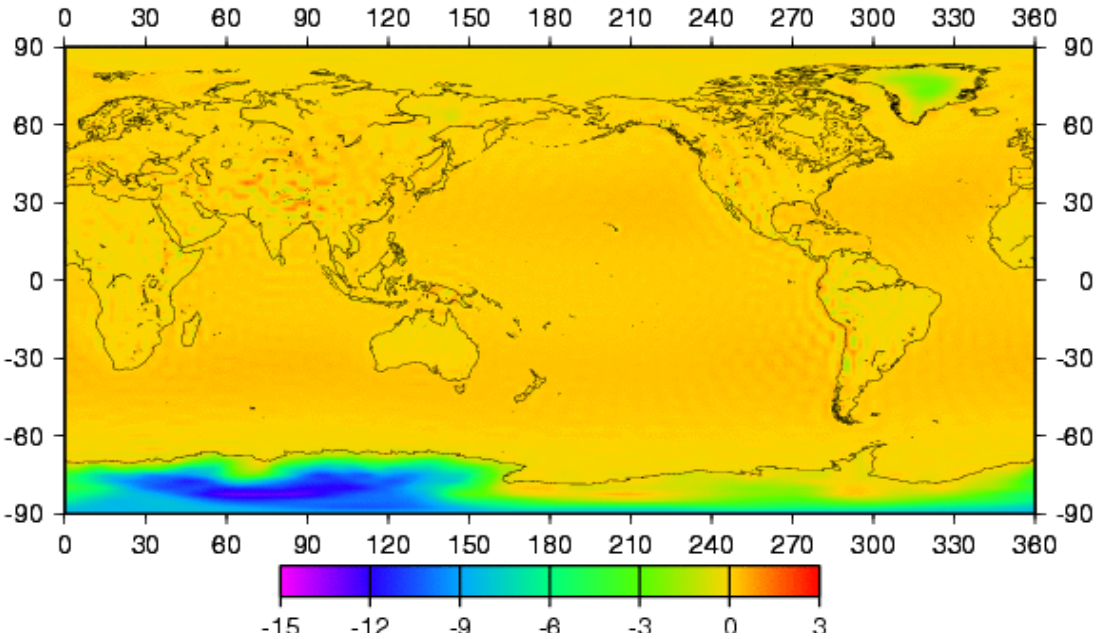
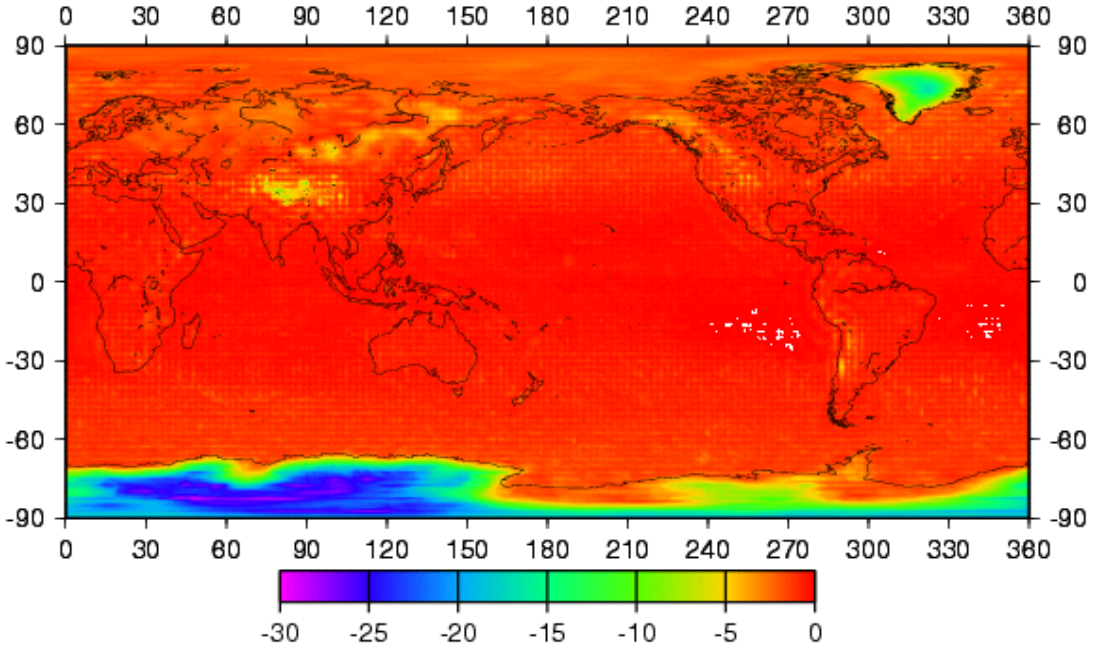
Status of Work

Differences between P1 and P3



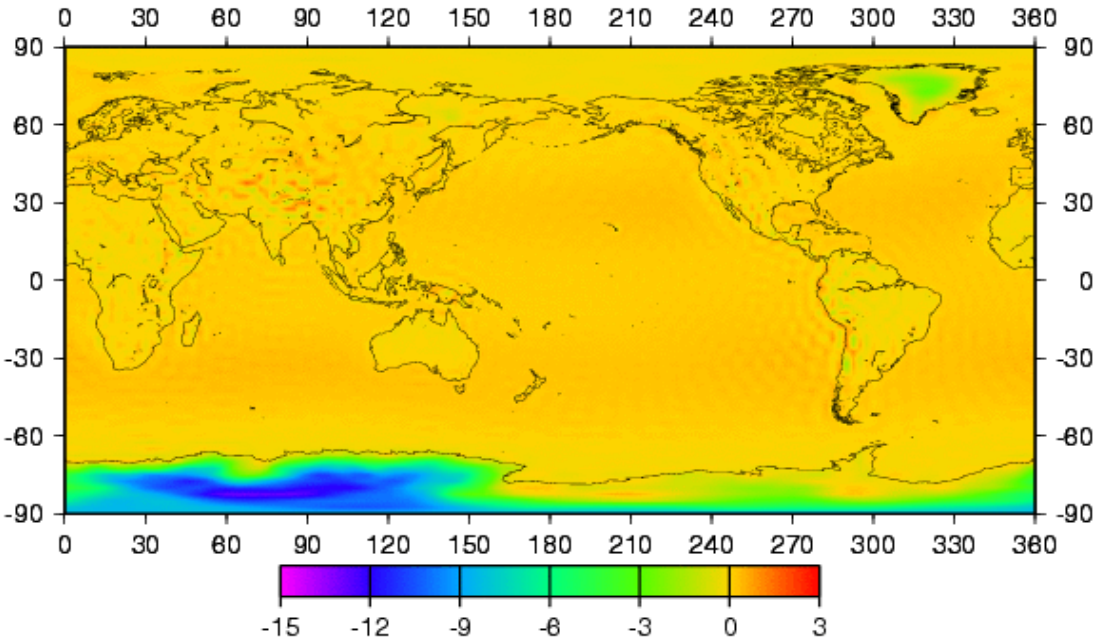
Mean bias



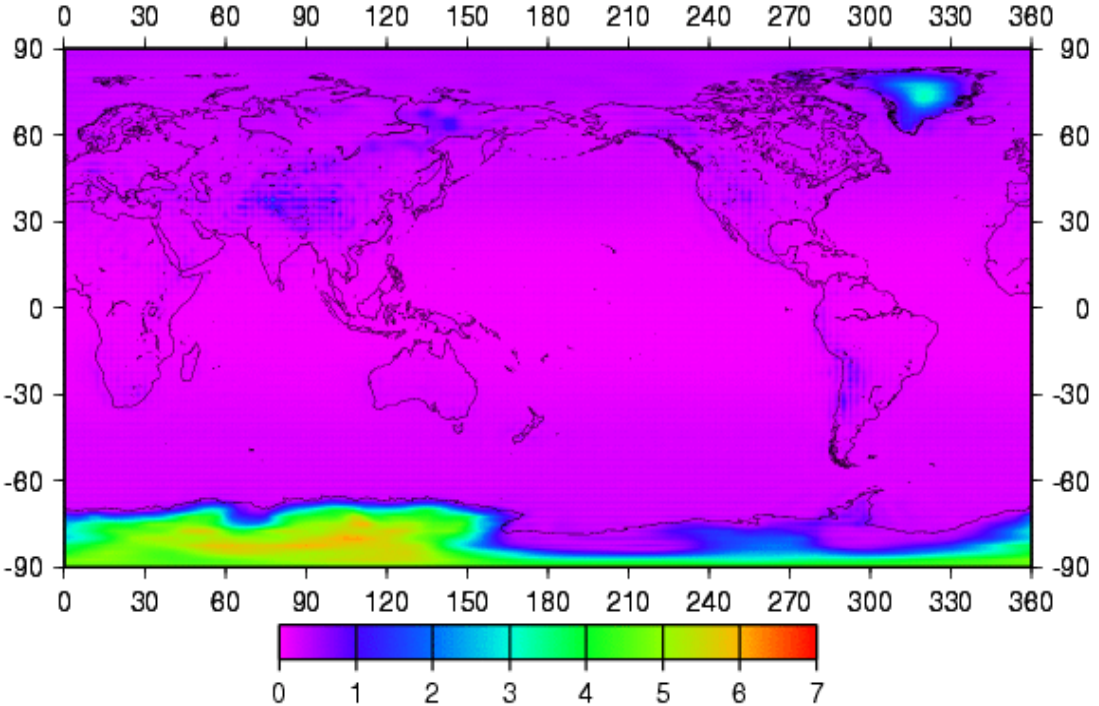
Maximum deviation

Status of Work

Differences between P1 and P3

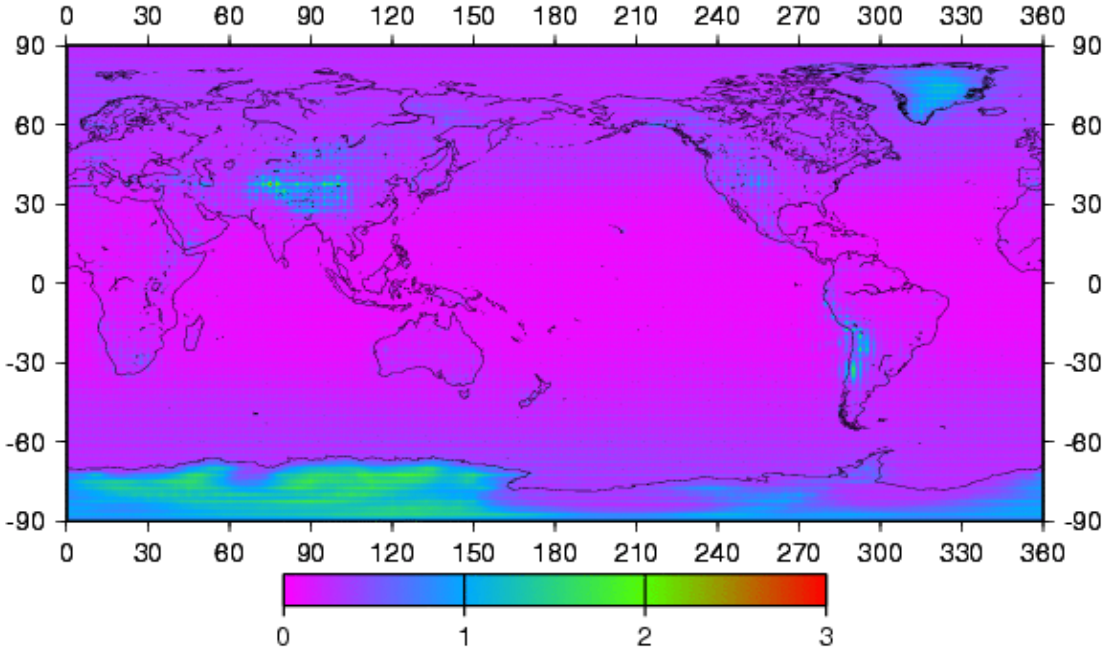


Mean



Standard deviation

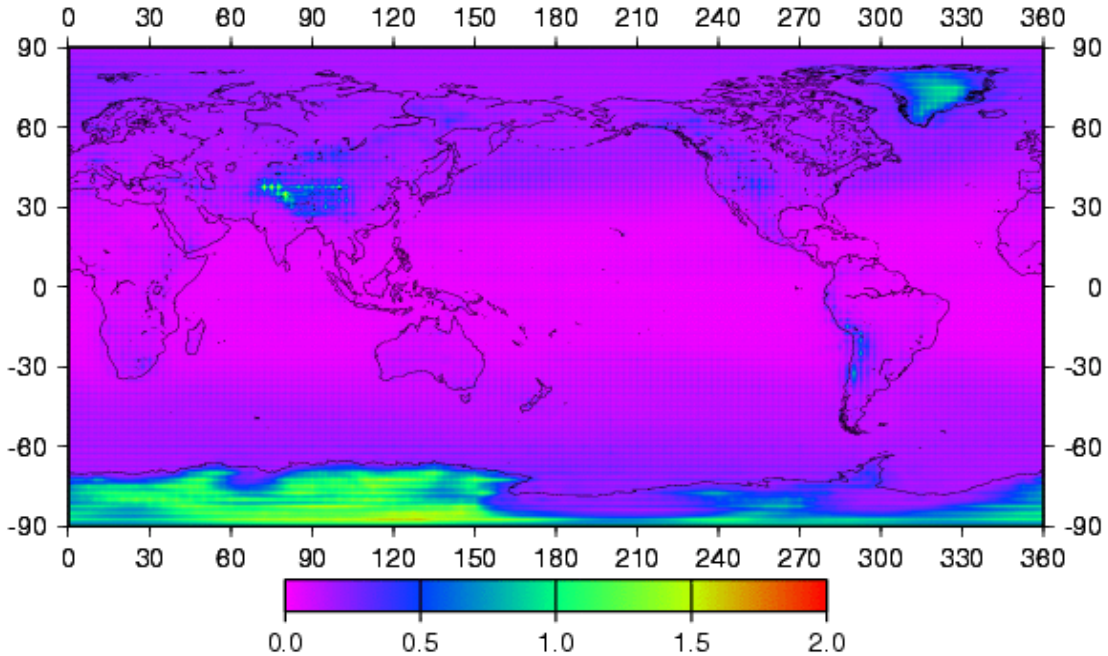
Status of Work



Differences between P1 and P3

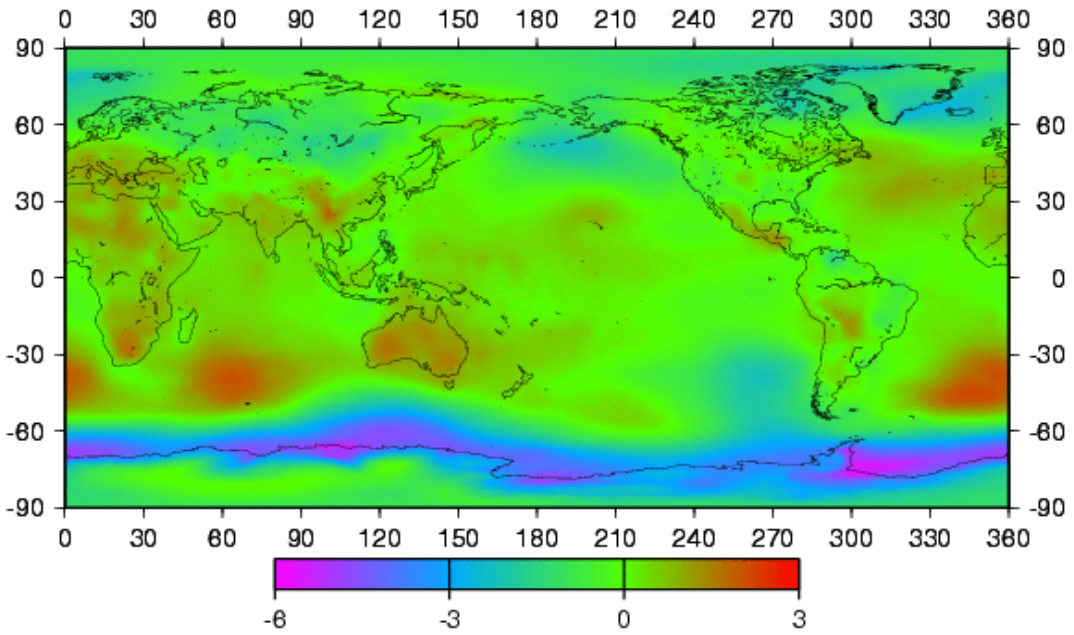
Daily ranges

Mean bias



Standard deviation

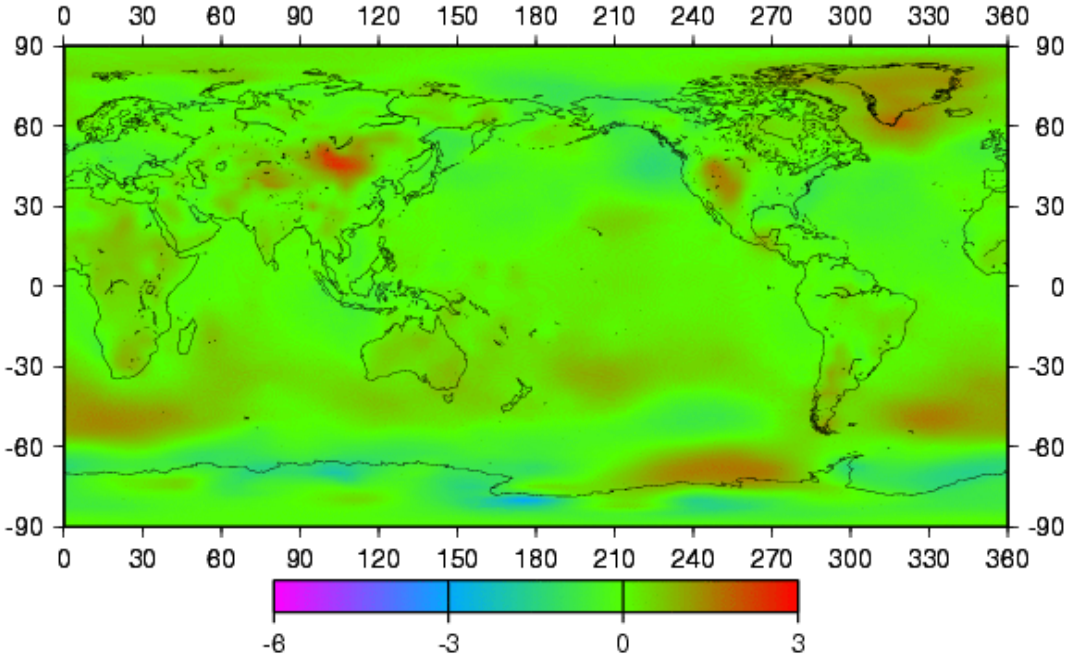
Status of Work



Reference surface

Differences of decadal mean from 42 year mean (1950 - 2001)

1962-1971



1982-1991

Urgent Steps

Result so far:

- P1 highly inaccurate over ice and other high land surfaces.
- **DO NOT USE SEA SURFACE PRESSURE OVER LAND!**
- Significant decadal pressure variations.

Necessary urgent improvement:

- Use P3 for operational (in progress).
- Take into account high resolution topography (in progress).
- Decide on time window for reference surface (IERS).
- Decide on formats (e.g. for GAMIT, GIPSY, BERNESE, others).

Long-term vision

Activities of the SBL:

- Continue work on AGILE (*all SBs*).
- Continue PGR-FPG (*together with SB Mantle*)
- Complete error budget for air pressure loading.
- Complete error budget for other loading.
- Implement more comprehensive Earth (system) model (based on modular model).
- More long-term: Include gravity and Earth rotation variations.
- More software.

Organizational issues:

- Consolidate SBL membership.
- Improve interaction with other Sbs (particularly hydrology, ocean, mantle).
- Solicit contributions from other groups (for example, ocean model and loading signal in gravity field).