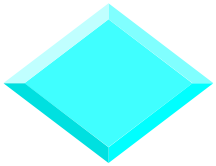

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A Practical Method to Correct The Gravity Effects of Fluid Envelopments of The Earth Using Satellite Gravity Data

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Contents

- *Geophysical corrections for precise gravity measurements*
- *Methodology of the use of satellite gravity data for the corrections*
- *Some problems*
- *Conclusion*

Precise Gravimetry

Matsusiro, Japan

Superconducting Gravimeter (SG)

Sensitivity - better than one ngal.

Stability - a few μ gals / year

Absolute Gravimeter (AG)

Single drop - a few μ gals

Set value - better than one μ gals

Long term gravity changes

Polar motion effects

Post-glacial rebounds

Tectonic events

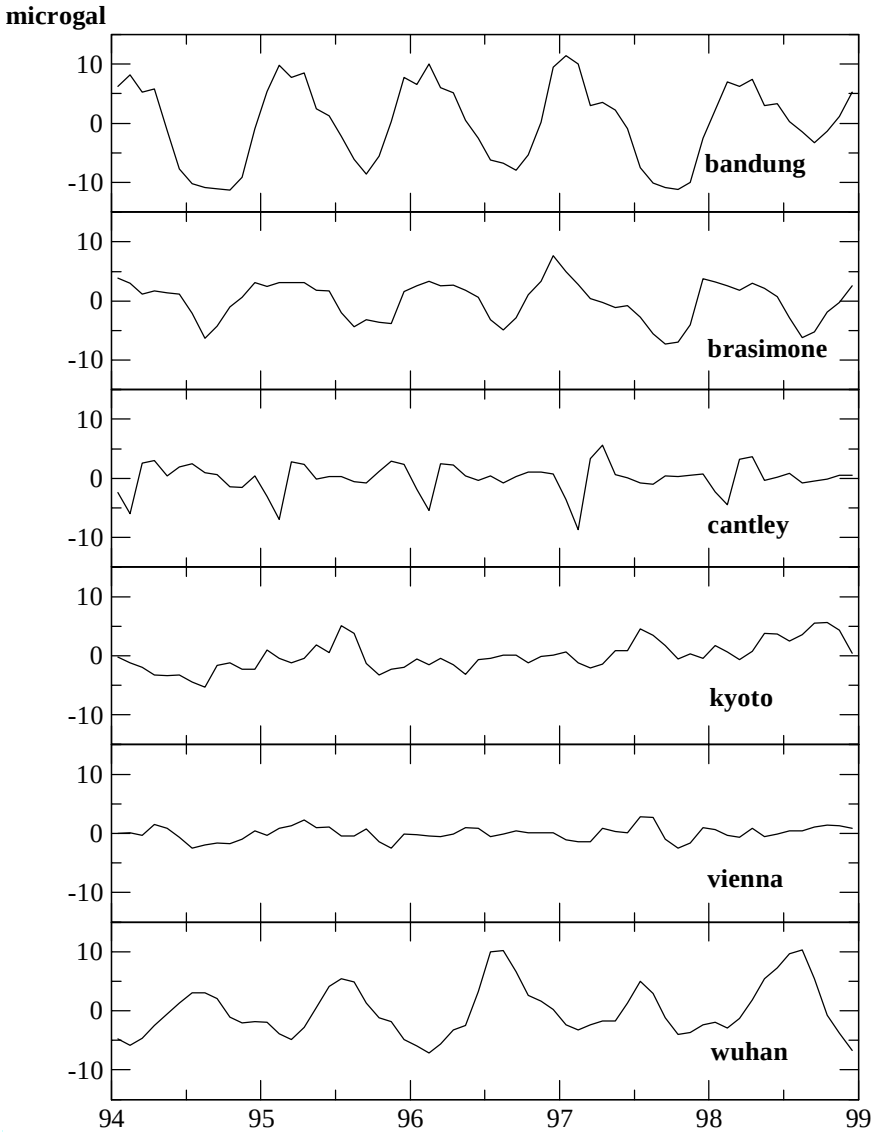
Sea level changes

Geophysical corrections

Corrections for precise gravity measurements

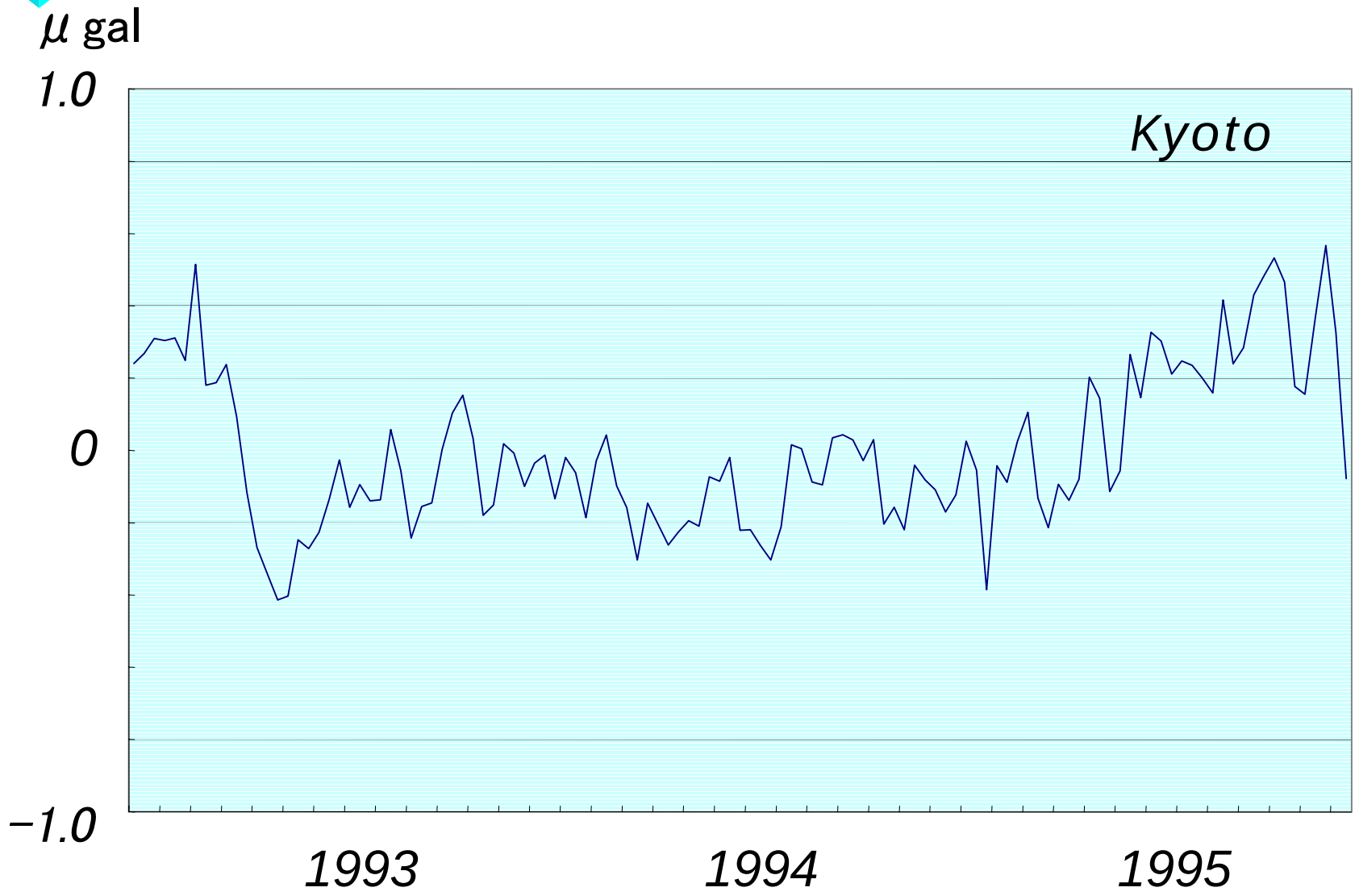
phenomena	typical period	amplitude (μgal)	accuracy of correction	remarks
earth tides	semi dianal	100	◎	
	dianal			
ocean tides	semi dianal	10	○	ocean tide models
	dianal			
atmospheric	dianal	a few	○	site measurements
pressure	a few days			reanalysis data set
	annual			
groundwater	annual	10	○／△	groudwater level
(local)				
groundwater	annual	a few	△	van Dam et al, 2001
(global)				
sea surface height	monthly	1～2	△	Sato et al, 2001
	annual			
polar motion	annual	a few	◎	EOP data

Gravity effects of Water Storage



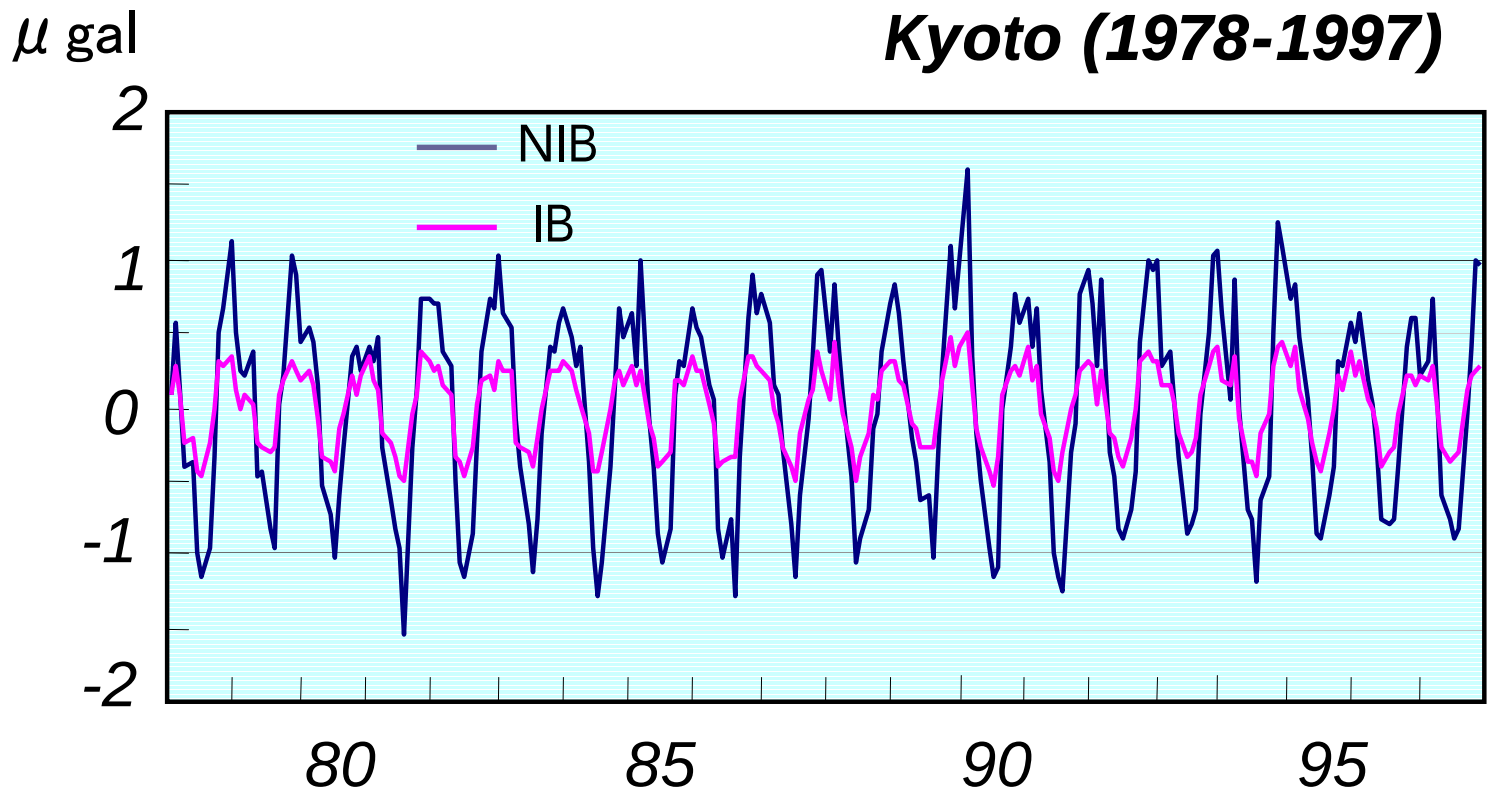
After T. van Dam *et al.*, 2001

Gravity Effects Due to Sea Surface Height Changes



Calculated from POCM SSH (Steric effects are corrected)

Gravity Effects of Surface Pressure



Calculated from NCEP/NCAR manthly mean surface pressure data.

GRACE data

- Suppose monthly average of $c_{l,m}$, $s_{l,m}$ **(l,m<100)** will be available
- Suitable for **global ocean effects** and **land water effects**.
- Insufficient for **atmospheric mass** effects, but maybe possible to include it.
- Global **mass conservation** is automatically achieved.

Methodology (1)

$(c_{l,m}(t), s_{l,m}(t))$ $(l,m<100)$ are given

$$\begin{pmatrix} \Delta C_{l,m}(t) \\ \Delta S_{l,m}(t) \end{pmatrix} = \begin{pmatrix} C_{l,m}(t) \\ S_{l,m}(t) \end{pmatrix} - \begin{pmatrix} \overline{C}_{l,m} \\ \overline{S}_{l,m} \end{pmatrix}$$

where $(\overline{c}_{l,m}, \overline{s}_{l,m})$ represent

a kind of average fields.

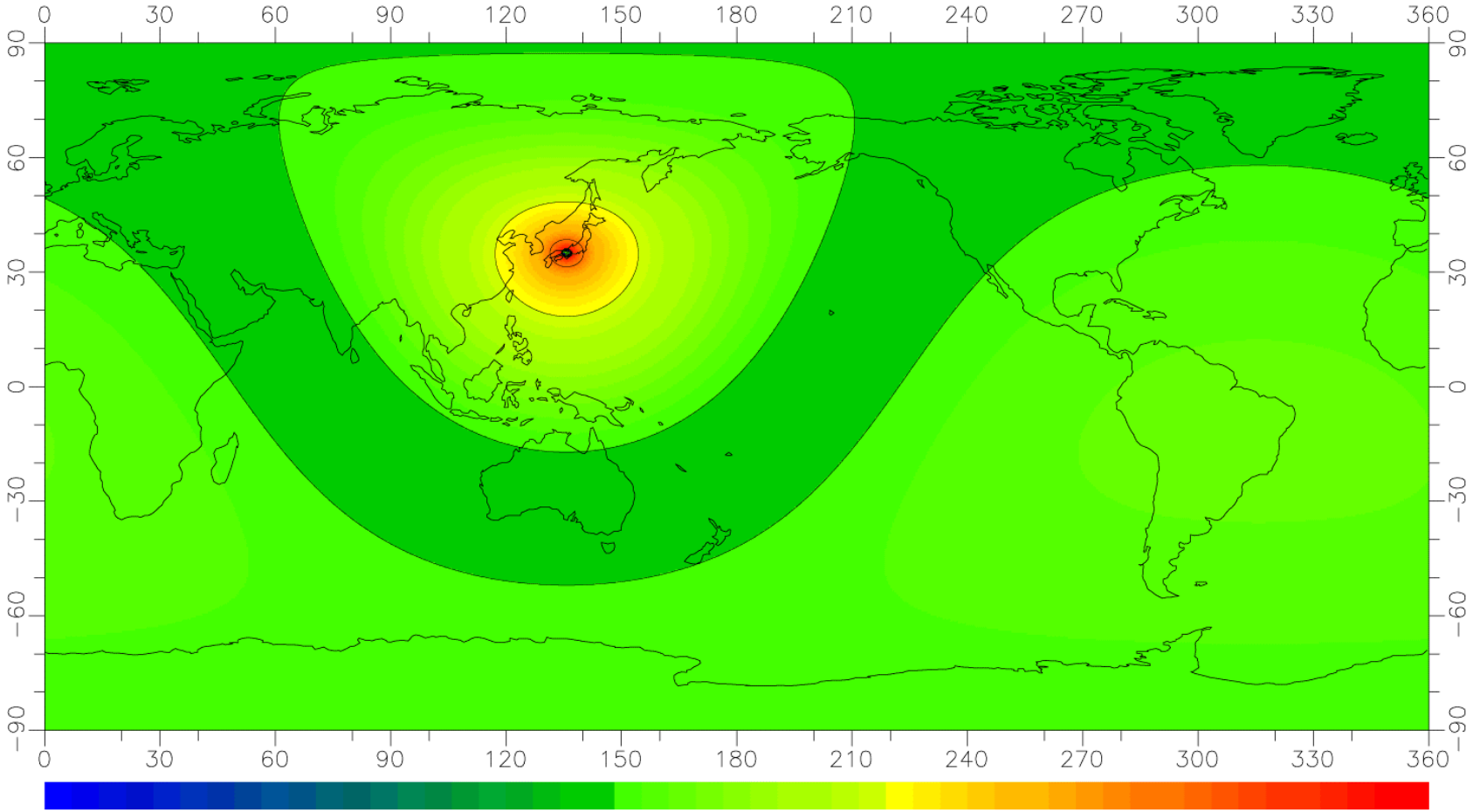
Methodology (2)

Then, we can calculate **equivalent surface masses**

$$\Delta\sigma(\theta,\phi,t) = \frac{a\rho_{ave}}{3}\sum_{l=1}^{n}\sum_{m=0}^{l} P_{l,m}(\cos\theta)\frac{2l+1}{l+k_l}(\Delta C_{l,m}(t)\cos(m\phi) + \Delta S_{l,m}(t)\sin(m\phi))$$

Finally, gravity effects can be calculated by **convolving Farrell's Green's functions** with the surface masses over the entire globe **except near field** (e.g. within 1 deg).

Green's Functions



Discussions (1)

Which is the best for the average (zero) field ,

- EGM 20xx like standard model, or
- the average values after some years of GRACE mission, or
- the values at a specific epoch (ex. 2001.x.x) ?

What is the meaning of the residual gravity ?

- Because all the global effects are included in the satellite data, only local phenomena, e.g. gravity changes due to tectonic events, are observed in the residual gravity signal.

Discussions (2)

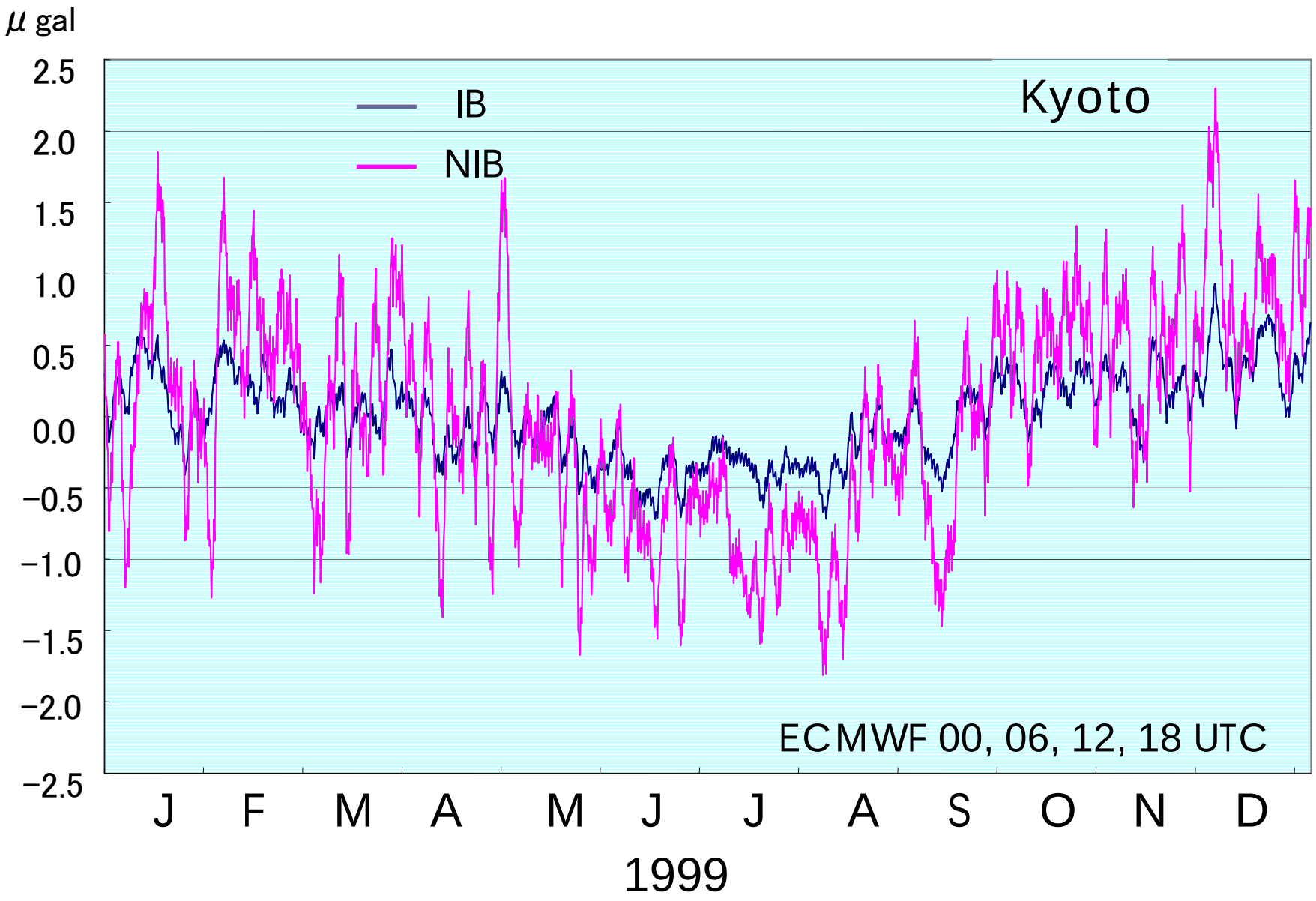
Effects of atmospheric pressure

- It may be theoretically rigorous to remove the effects beforehand, but same Green's function practically can be used for the far field effects.

-As long as the atmospheric effects being included, we do not mind IB/NIB hypotheses nor global mass conservation.

- For the corrections of high frequency gravity effects or local effects, we need surface pressure data.

Gravity Effects of Surface Pressure (Far Field)



Conclusion

GRACE data will be applicable for the corrections of the global gravity effects due to mass movements in Hydrosphere.

If the corrections causes better results for local phenomena, it indirectly validates the satellite gravity data.

For local effects (groundwater, sea level, surface pressure), we need observations.

We need a new definition of the average field to determine an absolute gravity value.