ARSC & IARC Report Part 2

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1: International Arctic Research Center, 2: Arctic Region Supercomputing Center
1. ARSC ASM Computing - Roberts/Kulchitsky

2. Coupler noise considerations - Roberts
1. The ARSC ASM Computing Environment

A full description of the ARSC ASM computing environment is available at:

http://data.arsc.edu/asm

A brief tutorial on using the repository will be given tomorrow.
1. ARSC ASM Computing - Roberts/Kulchitsky

2. Coupler noise considerations - Roberts
3. Coupler noise considerations

Continuing from the December 2007 meeting....

Hexagonal Buoy Arrays (circles indicate end position)

2007 SEDNA 70km array deployed March 24 (ends Oct–Nov 2007)
2007 SEDNA 10km array deployed March 24 (ends Oct–Nov 2007)
2006 SITii 18km array deployed September 7 (ends Aug 2007)
3. Coupler noise considerations

Sea Ice Dynamics Validation

![Graphs showing power spectral density over frequency for SEDNA and SITII buoy arrays.](image)
3. Coupler noise considerations

Sea Ice Dynamics Validation

[Sea Ice Matlab validation metrics package]
3. Coupler noise considerations

Sea Ice Dynamics Validation

ERA40 MSLP 6 hourly data spline interpolated to 1 hourly data

Effective bandwidth = 0.125 cycles day$^{-1}$

$N = 8640$, 1 hour samples (window = 192)

95% confidence
3. Coupler noise considerations

Sea Ice Dynamics Validation

Filtered to avoid exciting the ice-ocean boundary layer at the inertial (resonant) frequency that is also close to the M2 and S2 tidal frequencies.
When coupling models, a false signal at twice the update frequency needs to be considered. It is a potential source of numerical noise that is difficult to filter in real time.
3. Coupler noise considerations

Temporal Coupling Noise

There are no quick fixes to removing artificial signals as a result of infrequent coupler communication, since both FIR (left) and IIR filters (right) have a delay in real time. The best antidote is frequent coupler communication.
The temporal aliasing problem is indicative of a potentially larger problem in ice-ocean-atmospheric coupling that is probably highly dependent on boundary layer formulations.
3. Coupler noise considerations

Classical quadratic formulations probably act as a natural filter by passing noise to the oceanic boundary layer. For example:

$$\tilde{\tau}_w = \rho_w C_{W_g} |\tilde{u}_{w_g} - \tilde{u}| \left[(\tilde{u}_{w_g} - \tilde{u}) \cos \varphi + k \times (\tilde{u}_{w_g} - \tilde{u}) \sin \varphi\right]$$

Where:
- $\tilde{\tau}_w$ = ice-water stress
- $\rho_w$ = sea water density
- $C_{W_g}$ = quadratic drag coefficient
- $\tilde{u}$ = ice velocity
- $\tilde{u}_{w_g}$ = geostrophic water velocity
- $\varphi$ = turning angle
- $k$ = unit vector normal to the surface.

But these can also filter out inertial oscillations.
On the other hand, we already know ‘mass transport ice-ocean models’ are sensitive to numerical noise (this was the reason for filtering model input in the first instance):

\[
\frac{\partial M_x}{\partial t} - f M_y - F_x = \frac{\tau_x}{\rho_w}
\]

\[
\frac{\partial M_y}{\partial t} - f M_x - F_y = \frac{\tau_y}{\rho_w}
\]

- $M$ - Ekman mass transport
- $f$ - Coriolis
- $\tau$ - Wind forcing
- $\rho$ - ice/water mix density
- $F$ - internal ice force (highly non-linear)
Does the potential of temporal noise extend to spatial aliasing?
3. Coupler noise considerations

Spatial Coupling Noise

Does the potential of temporal noise extend to spatial aliasing?

Probably, because the constitutive equation is highly non-linear:

\[ \hat{\sigma}_{mn} = hP^* \left[ \Phi_1 \hat{\varepsilon}_{mn} + \Phi_2 I_\varepsilon \delta_{mn} \right] \]

Where
- \( \hat{\sigma}_{mn} \) = internal stress tensor
- \( h \) = ice thickness
- \( P^* \) = Compressive strength
- \( \Phi_1 \) and \( \Phi_2 \) are invariant functions of the strain rate tensor \( \hat{\varepsilon}_{mn} \)
- \( I_\varepsilon \) is divergence
3. Coupler noise considerations

Spatial Coupling Noise

aligned

twisted

Longwave signal
3. Coupler noise considerations

<table>
<thead>
<tr>
<th>Signal</th>
<th>Aligned</th>
<th>Twisted</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Longwave signal" /></td>
<td><img src="image2" alt="Longwave signal aligned" /></td>
<td><img src="image3" alt="Longwave signal twisted" /></td>
</tr>
<tr>
<td><img src="image4" alt="Longwave divergence" /></td>
<td><img src="image5" alt="Longwave divergence aligned" /></td>
<td><img src="image6" alt="Longwave divergence twisted" /></td>
</tr>
</tbody>
</table>

**Spatial Coupling Noise**

**Longwave divergence**
3. Coupler noise considerations

Spatial Coupling Noise

signal
aligned
twisted

Shortwave divergence
3. Coupler noise considerations

Spatial Coupling Noise

high pass filtered u velocity component of wind on 14 km grid
• Currently setting up CPL7 to test for aliasing.

• Potential application for a perfect reconstruction spatial filter.

• Any advice or words of wisdom welcome.
Contacts

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