Martinez Planning Tide

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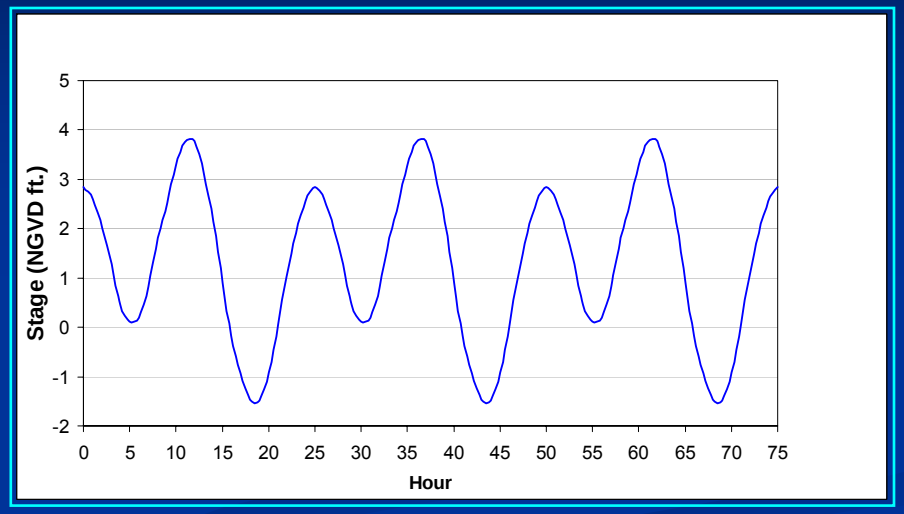
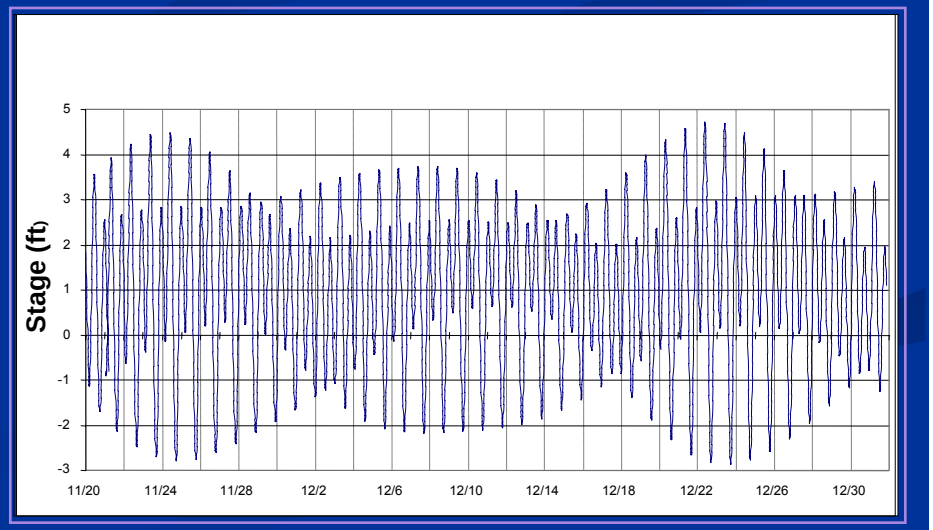
Why a planning tide?

- Replace "19-yr mean tide"
- Increase realism
- Need complete record
- Astronomical <u>may</u> not be adequate
- 2 estimators: stage and EC must be coupled





Thanks

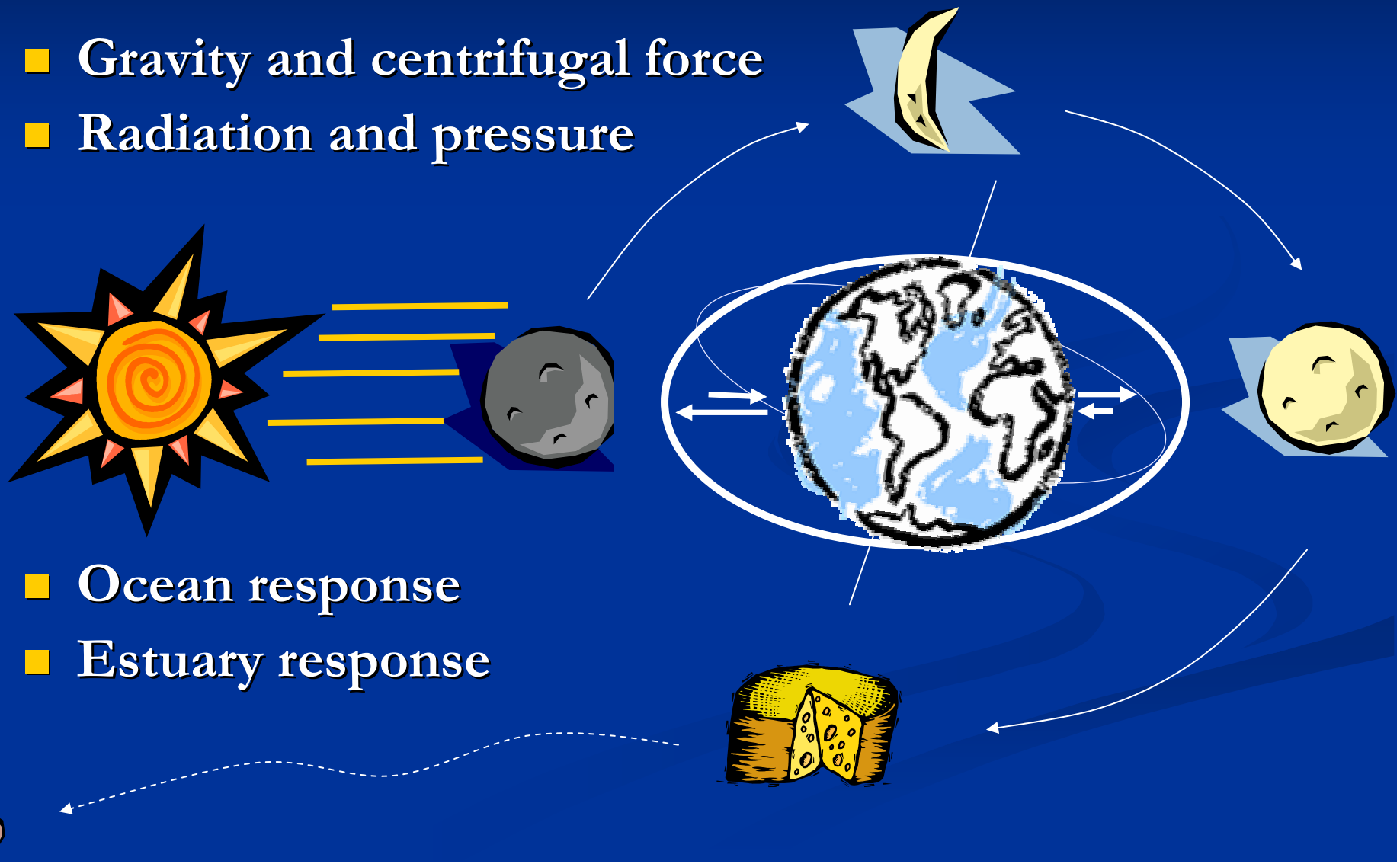
- Dr. Richard Denton, CCWD
  - G-Model and discussions of tides
- Bijaya Shrestha & Parviz Nader-Tehrani
  - Investigation of realistic planning tides

What is a good tidal boundary?

- Salinity/EC and water surface
- Independent from interior system
- Where the action isn't
- Data available
- You have to consider the model
  - Martinez is a compromise between 1D (better upstream) and independence from interior (better downstream)

What Causes Tides?

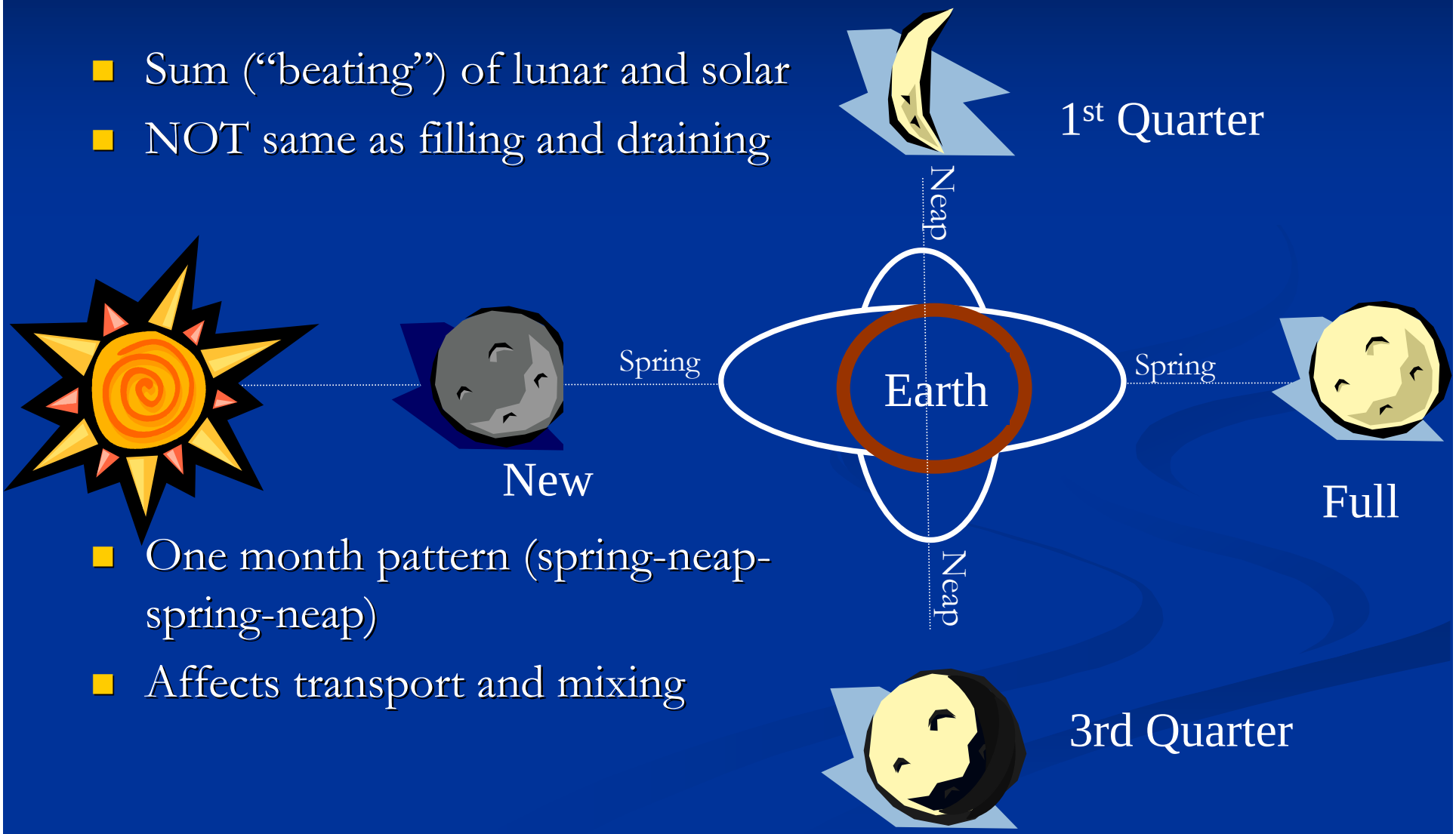
- Gravity and centrifugal force
- Radiation and pressure



- Ocean response
- Estuary response

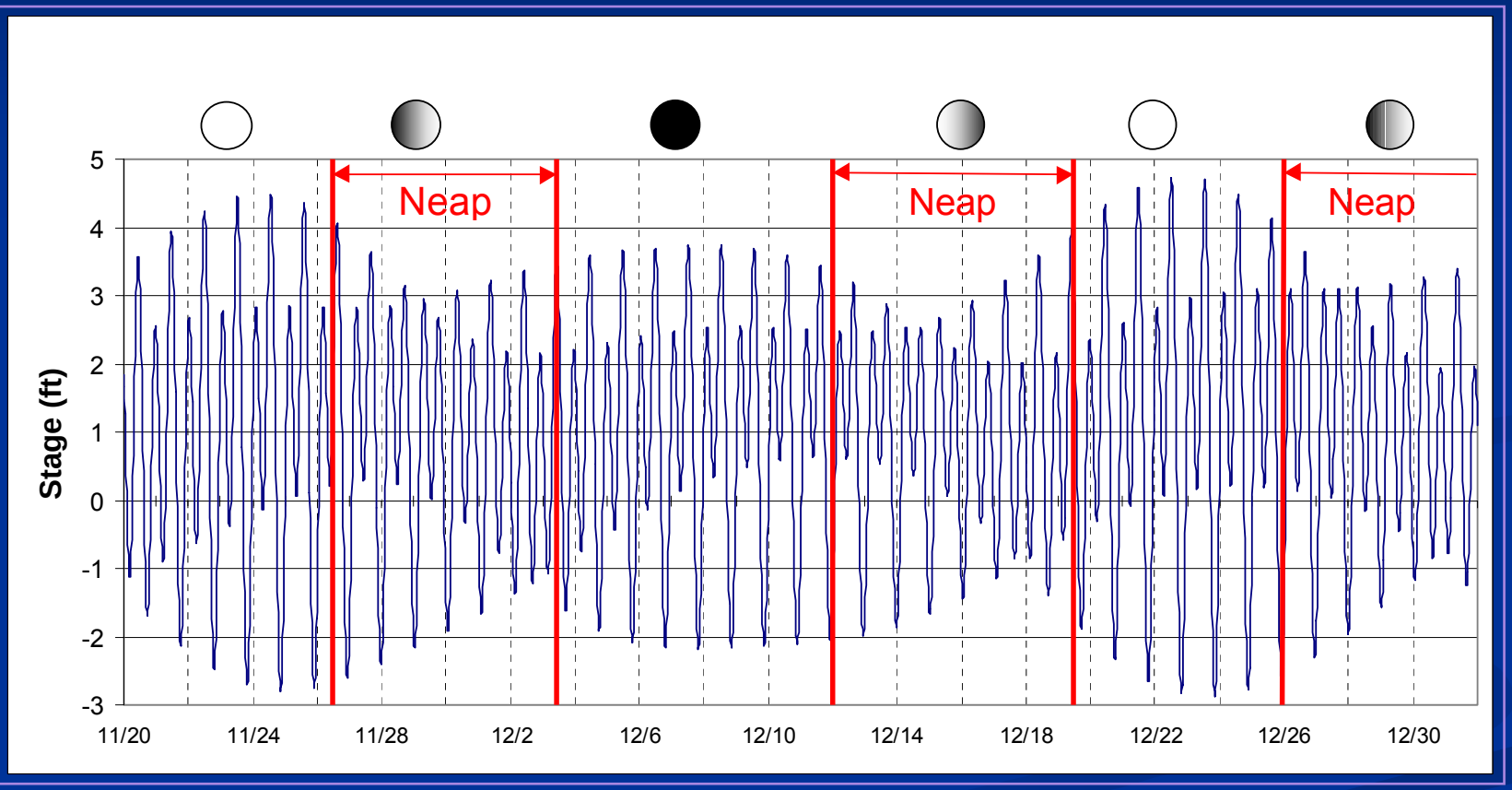
Spring-Neap Cycle

- Sum ("beating") of lunar and solar
- NOT same as filling and draining

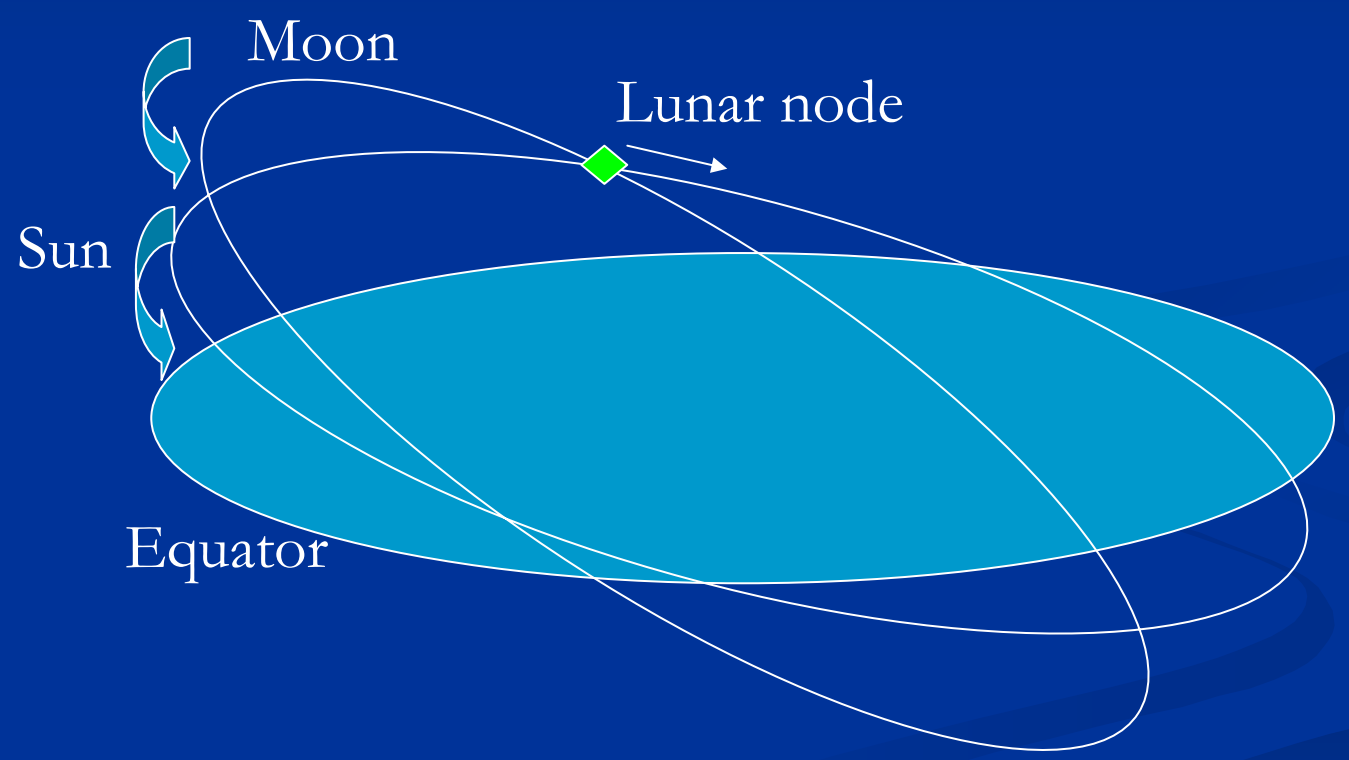


- One month pattern (spring-neap-spring-neap)
- Affects transport and mixing

Spring/Neap Tides



Where does that "19 years" come from anyway?



Equilibrium/Harmonic Tide

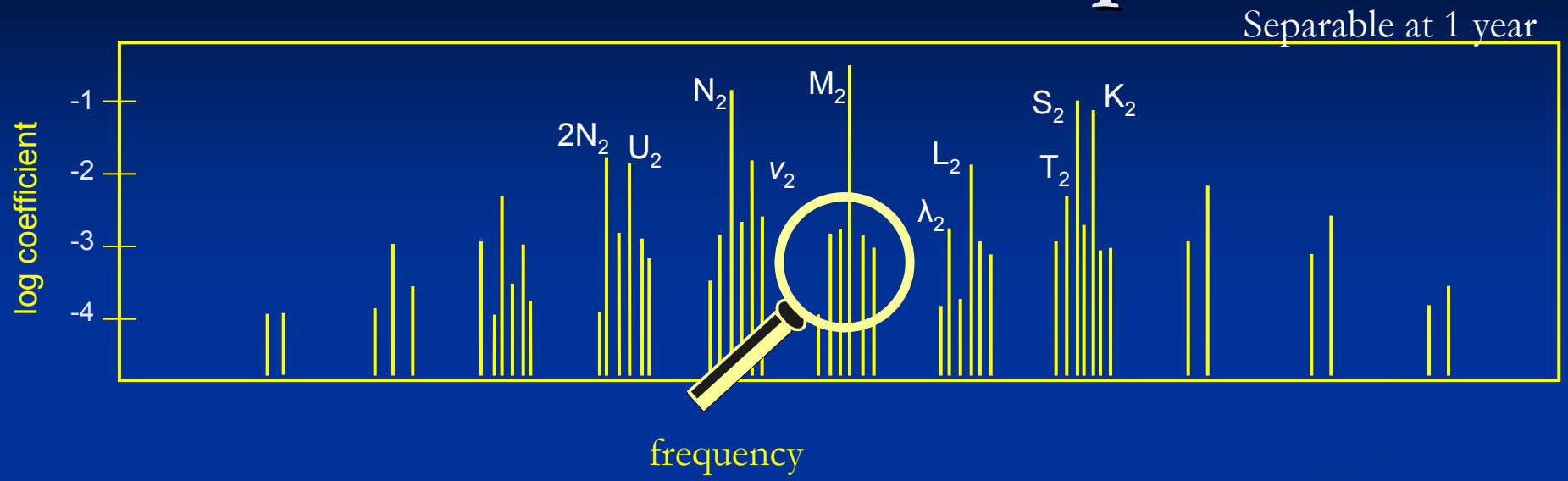
- Equilibrium: Ocean at equilibrium with forcing
- Spherical harmonic forcing (Ugly)
  - Decompose into cosine harmonics

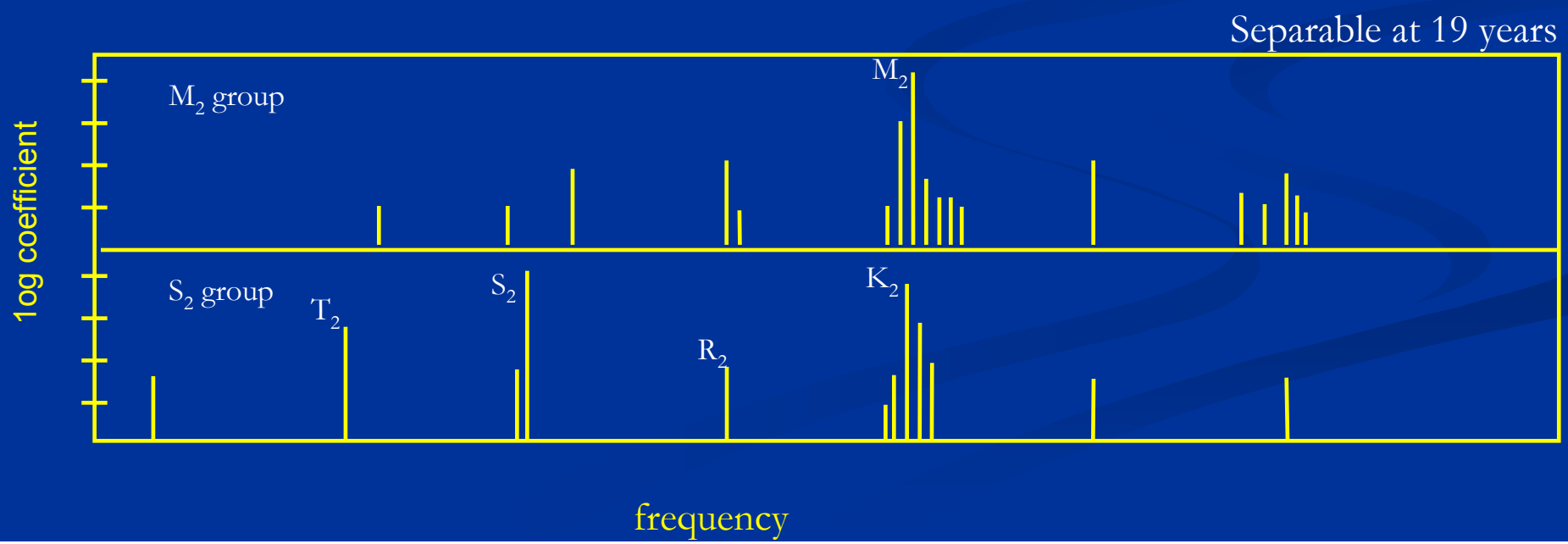
19-year nodal corrections.

$$z(t) = \sum_{i=1}^{N} f_i a_i \cos(\omega_i t + \phi_i + u_i)$$

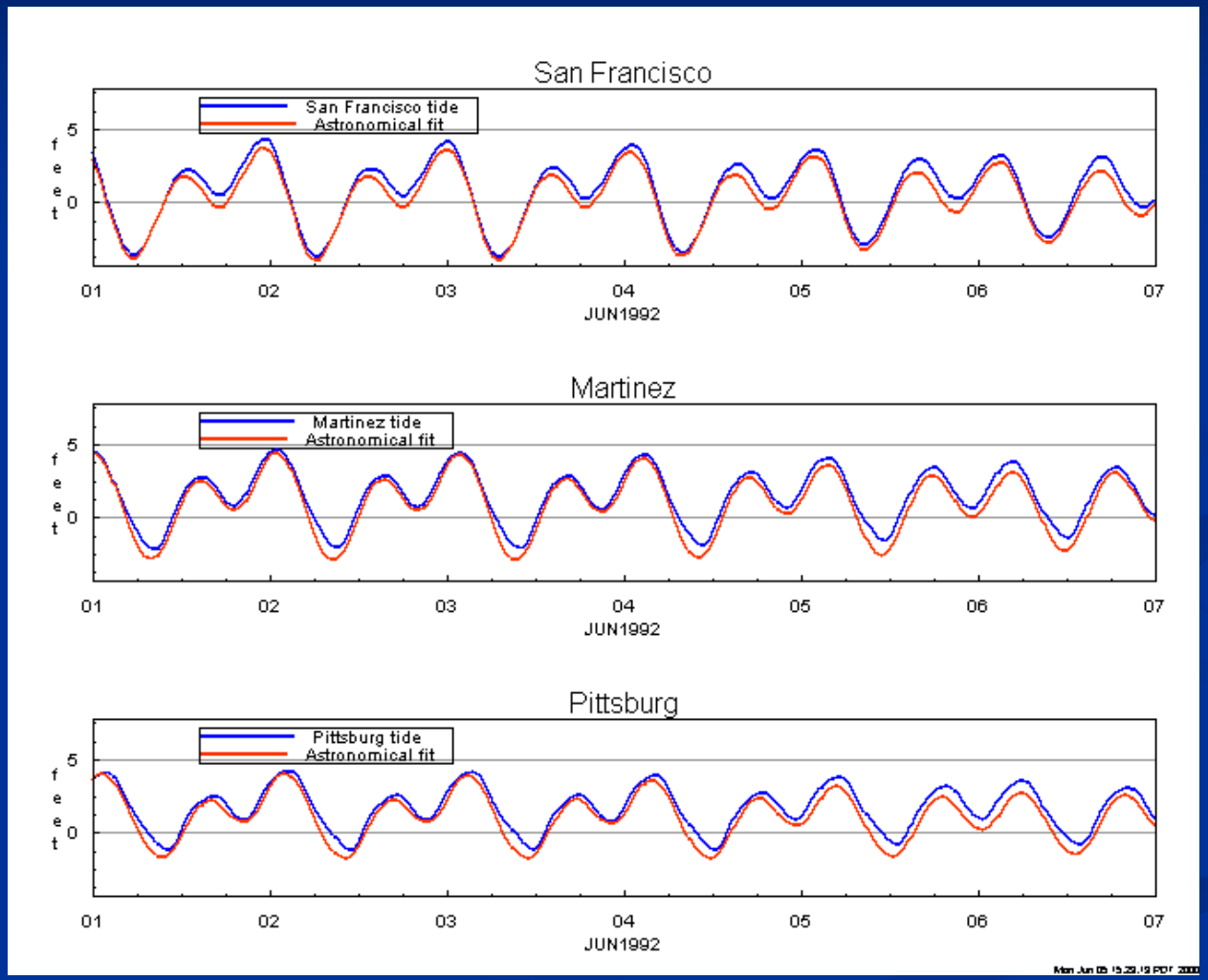
- Harmonic tide: Take the forcing frequencies, but allow different proportions
  - Empirical fit, no fluid dynamics

Constituent Groups

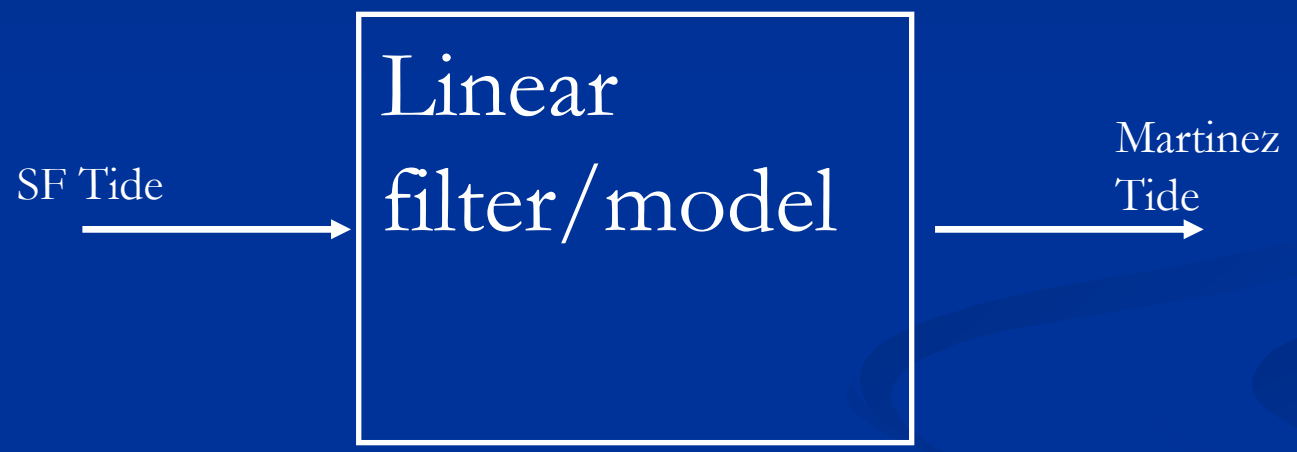




Astronomical Tide Captures A Lot



Alternative: "Linear System" approach



- What is a linear system?
  - Works on (lags, amplifies) each constituent frequency separately
  - Doesn't create new frequencies
  - Lots of familiar examples (e.g., moving average)

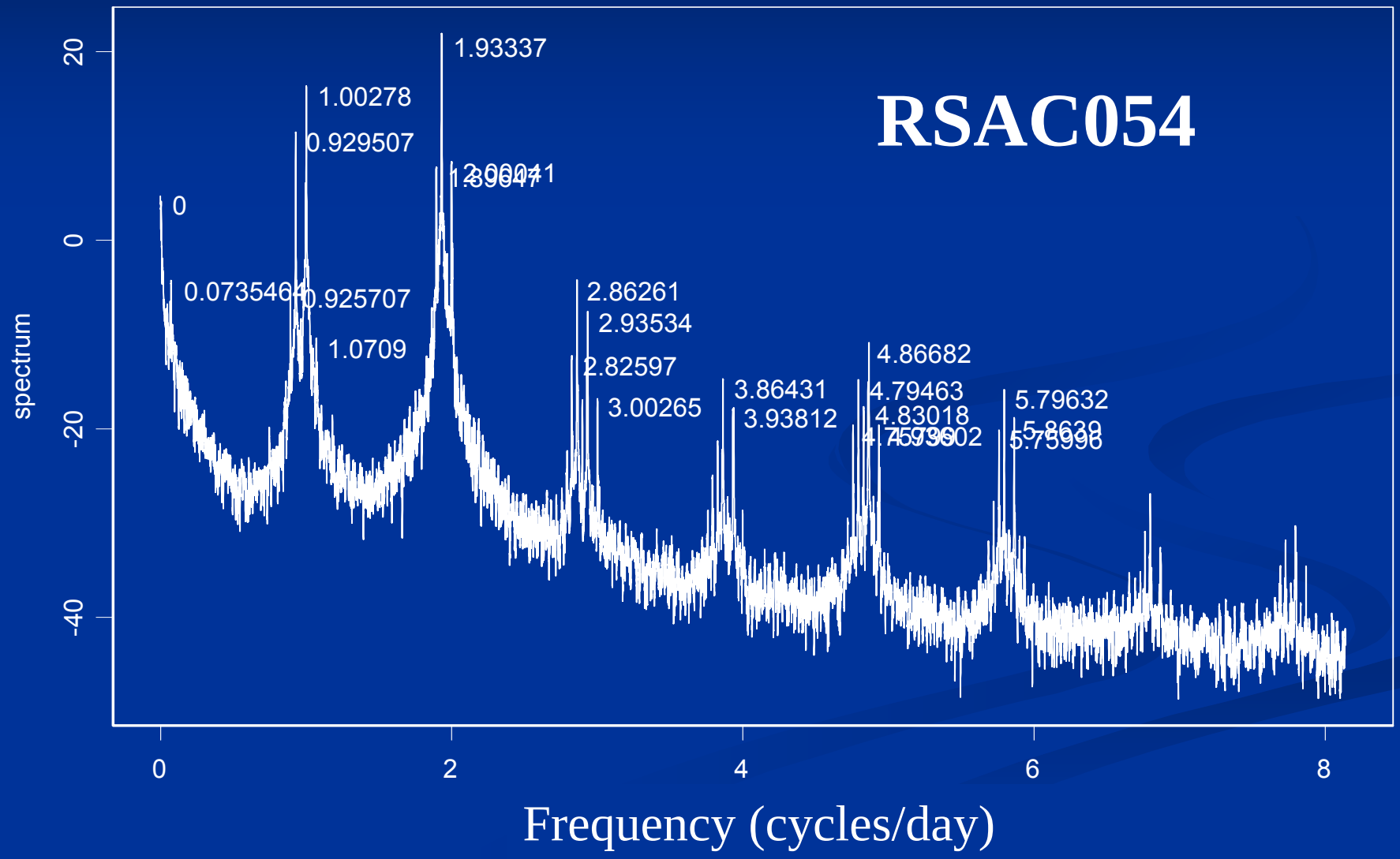
Residual Tide

- Seasons…solar radiation
- Overtides/shallow water frequencies
- 14 day/monthly cycles
  - Unreliable and hard to predict
  - Confounded
    - Pressure, spring-neap, wind, upstream hydrograph, occupation of the upper part of the tidal prism are all correlated
    - Spurious conclusions are very easy to come to!

Other Tidal Components

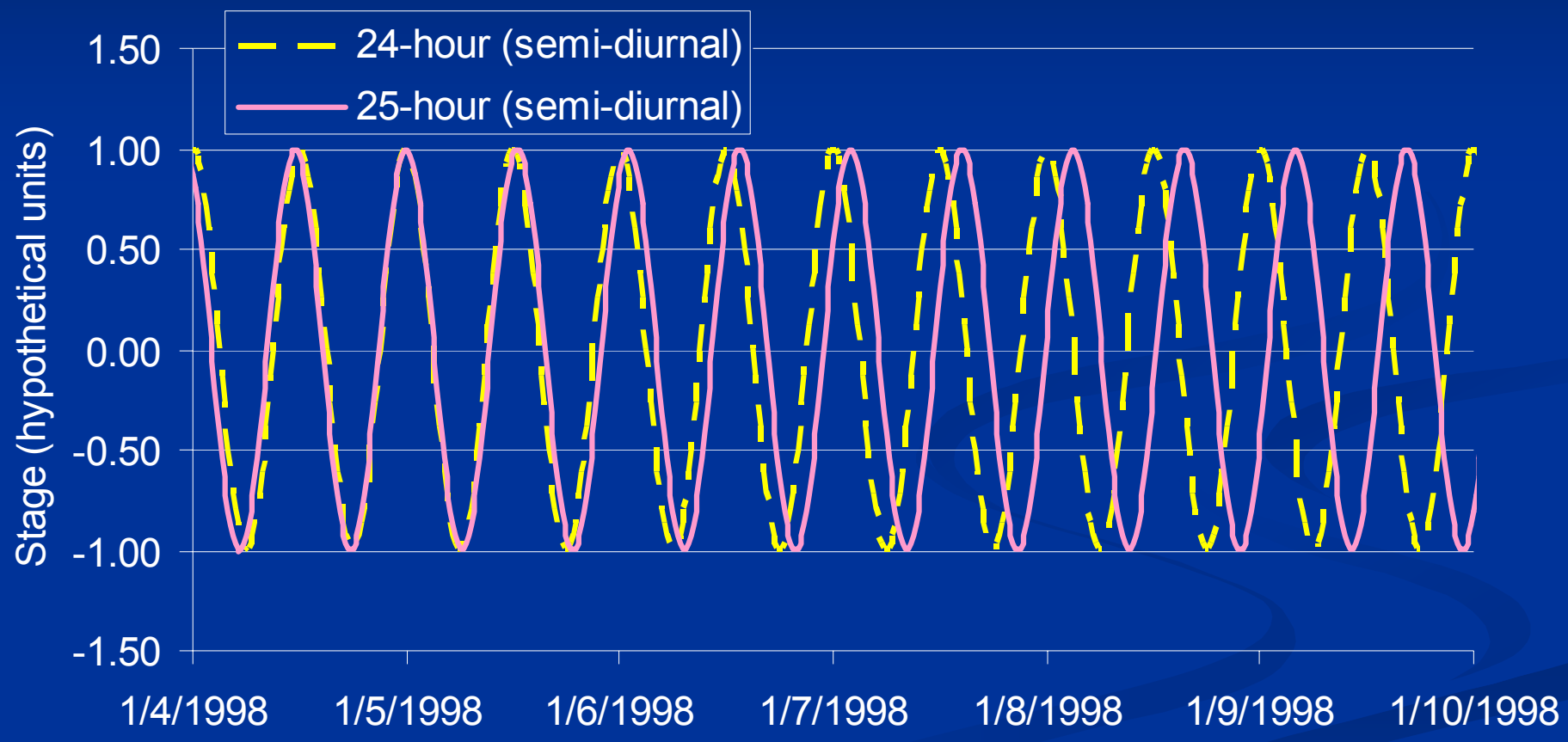
- Overtides/ shallow water friction
- Seasonal trends
- Barometric, non-linear and irregular forcing (e.g. filling and draining of Delta)
  - Unreliable and hard to predict
  - Confounded
    - Pressure, spring-neap, wind, upstream hydrograph, occupation of the upper part of the tidal prism are all correlated
    - Spurious conclusions are very easy to come to!

Tidal Frequencies Are Clustered



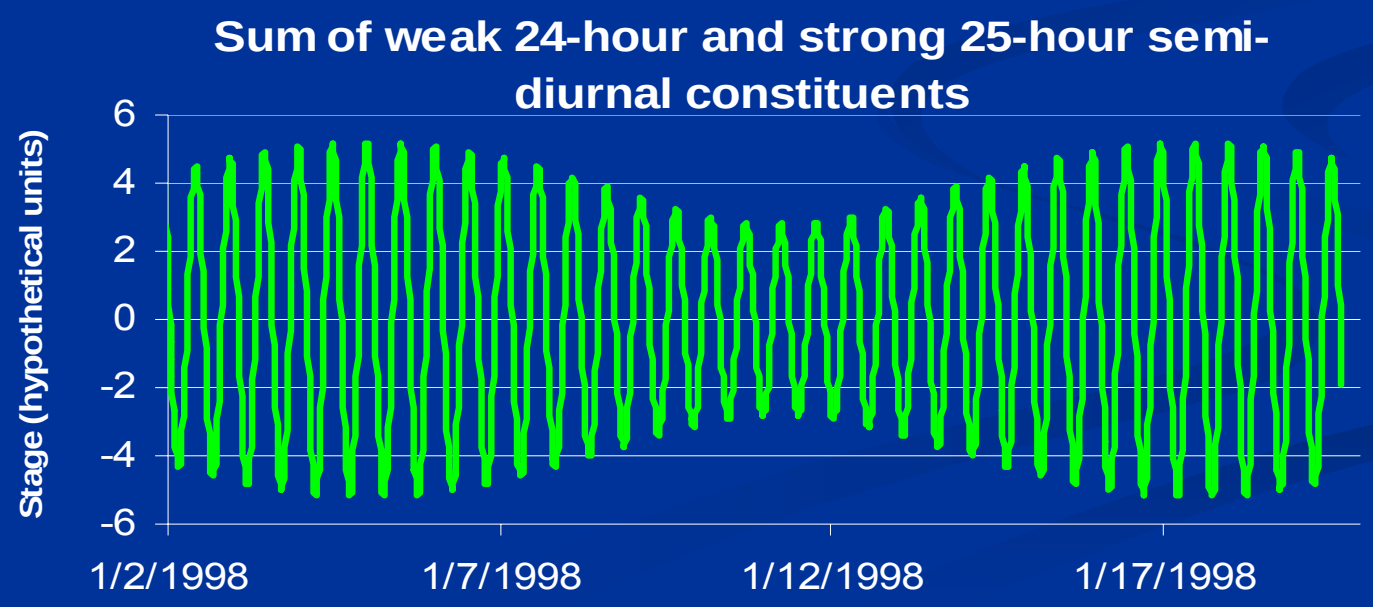
Nearby Frequencies

…are awfully frustrating

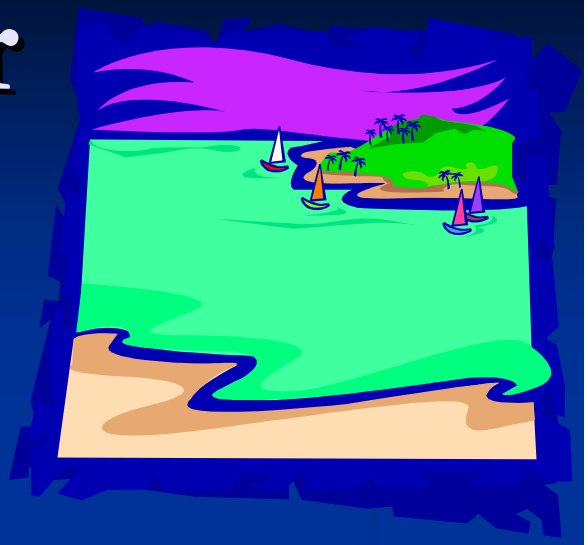


Combining Close Frequencies

- Looks like dominant (amplitude) frequency
- Modulated at low frequency
- NOAA node adjustments adjust small clusters to main constituents



Shallow Water



- "Quadratic" friction:

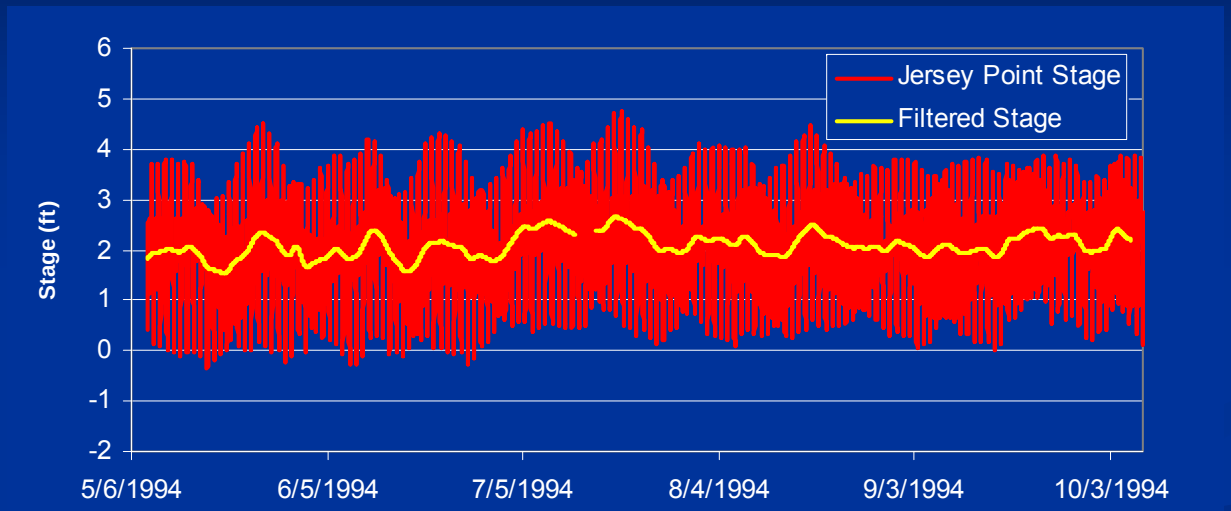
$$friction \propto Q|Q|$$

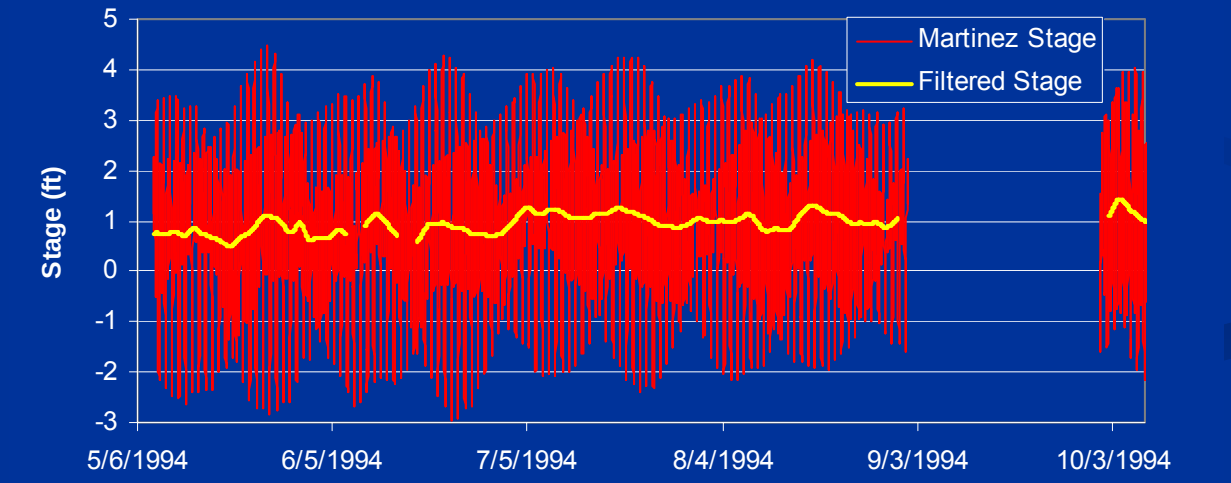
- Produces new frequencies:

$$\cos(u)\cos(v) = \tfrac{1}{2}[\cos(u+v) + \cos(u-v)]$$

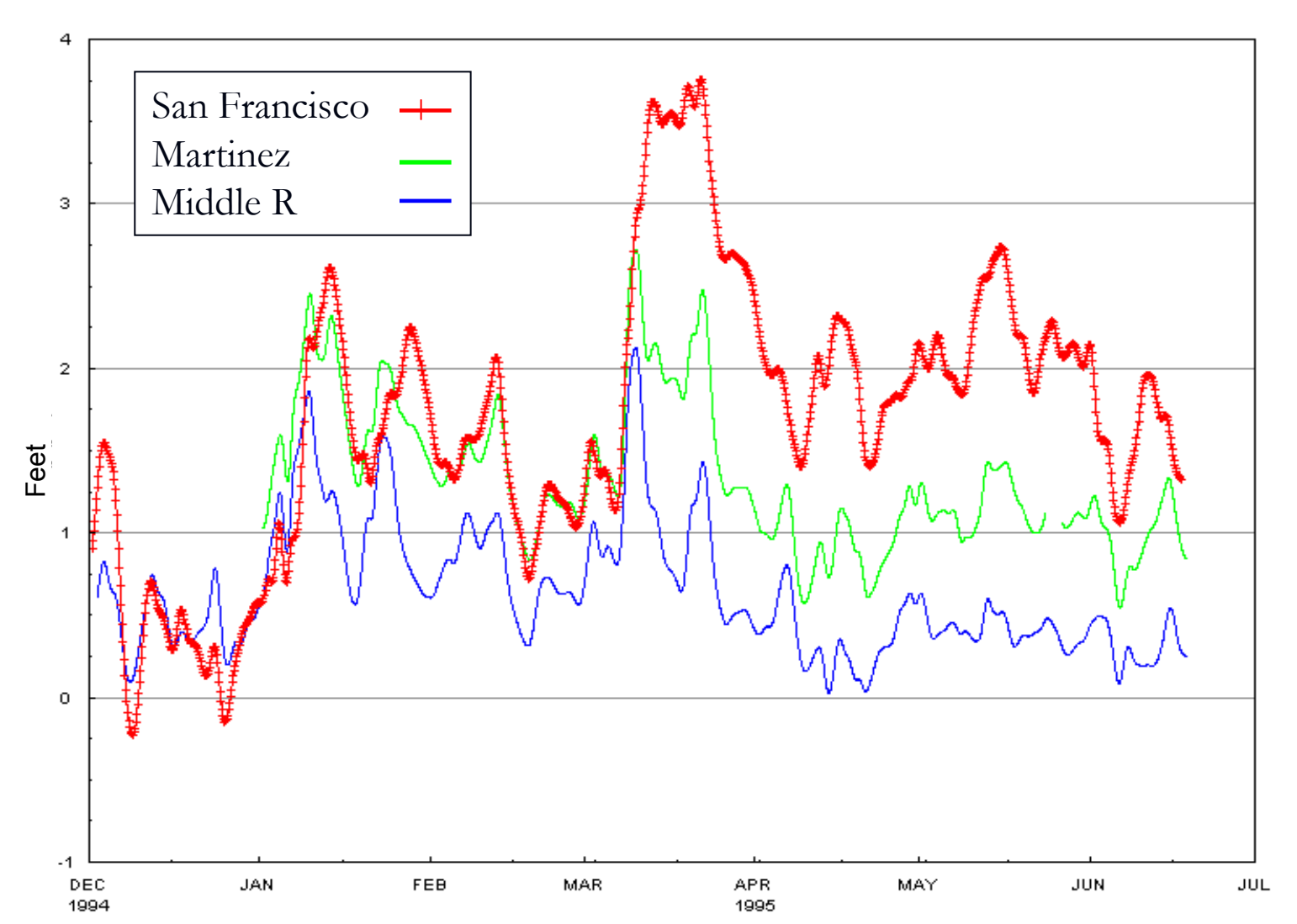
$$\cos(u+v) = \cos(u)\cos(v) - \sin(u)\sin(v)$$

Spring-Neap & Fill-Drain





Filtered Tide at 3 Stations



The Planning Tide: What We Have

- San Francisco data since early 1900s, few gaps
- Good astronomic models for San Francisco.
- Realistic astronomic models for Martinez.
- Martinez long-period residual looks like San Francisco

Planning Tide Methodology

- Use Martinez astronomical model for diurnal and semi-diurnal constituents
- Low-passed San Francisco data for long-period constituents (simple lagged model)
- Ignore shallow water frequencies
- Alternative: Martinez is a filtration of SF
- Alternative: Astro model of Martinez, call it a day

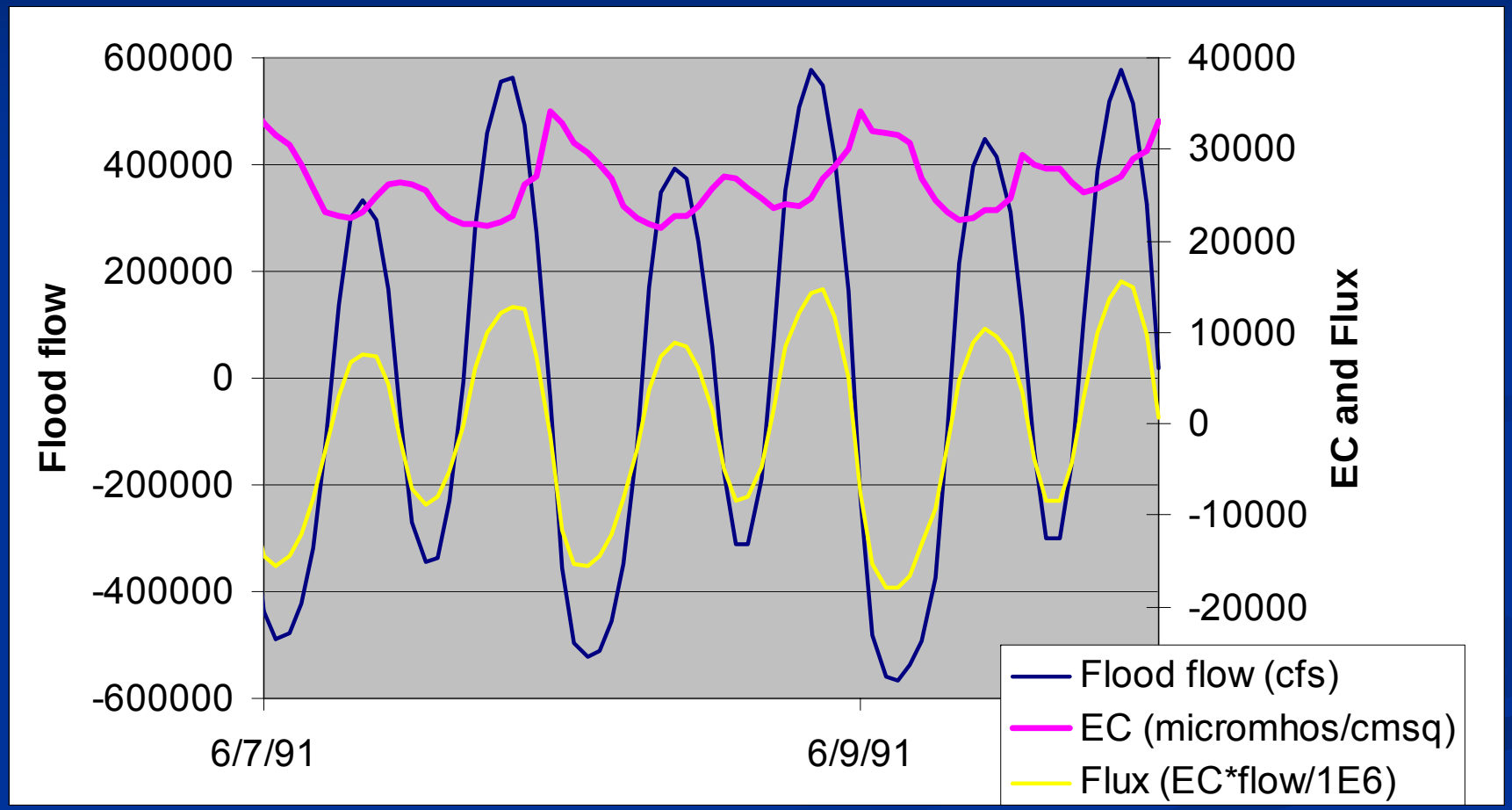
Shortcomings/Questions of The Stage Model

- Is the long period tide exogenous to the Delta and study?
  - Ocean barometric events and storms (inflow) related
  - Very large outflow may affect propagation of tide
- Are shallow water frequencies important?
  - Does it make a difference in current models
  - If not, should it?
- Could we simplify

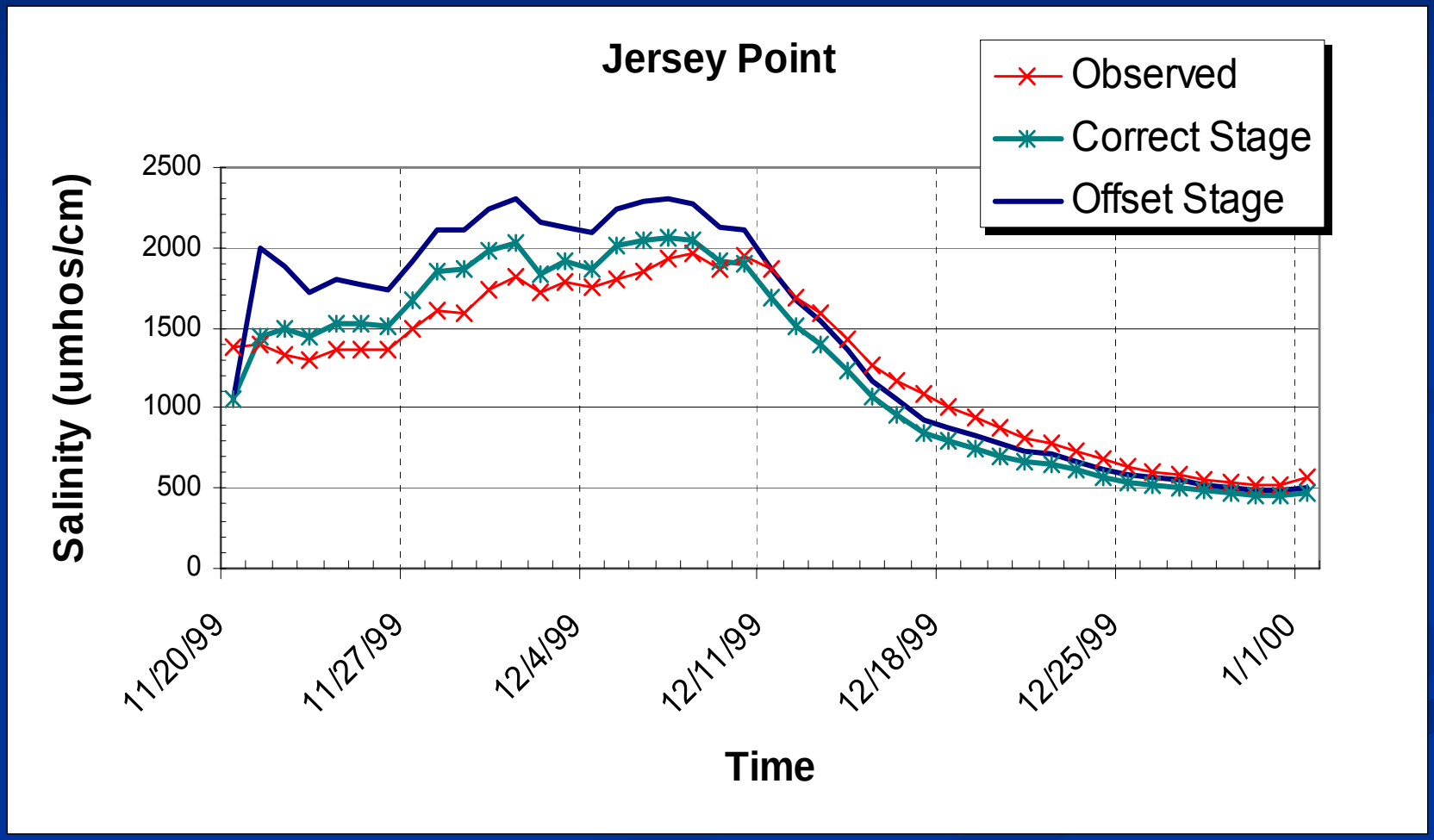
EC Model

- The model is empirical-conceptual
- Loosely based on G-model derivation
- Requirement: flow and EC be phased right

Salt flux: flow and EC

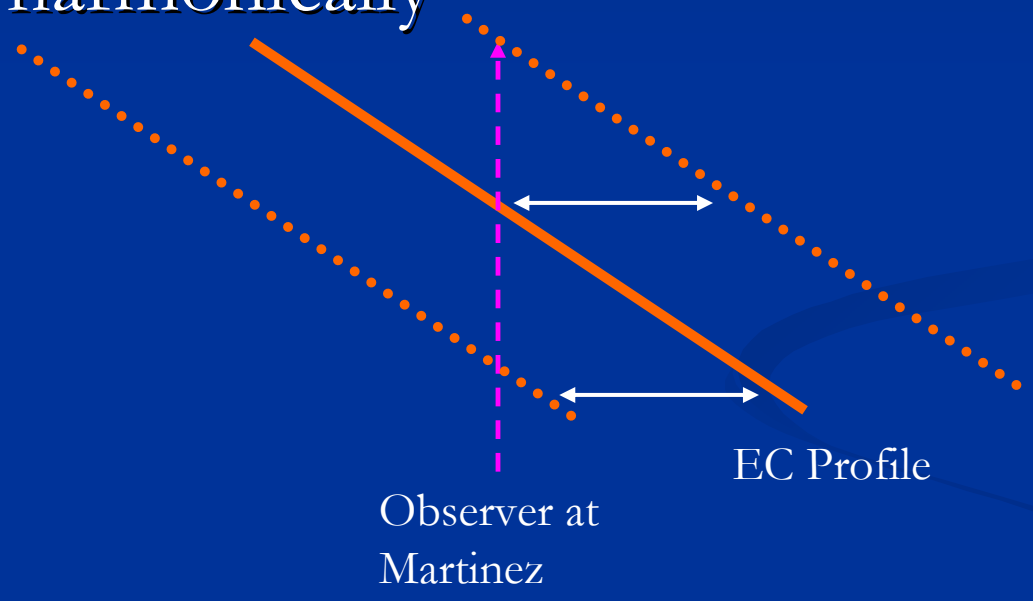


Sensitivity to Martinez Stage

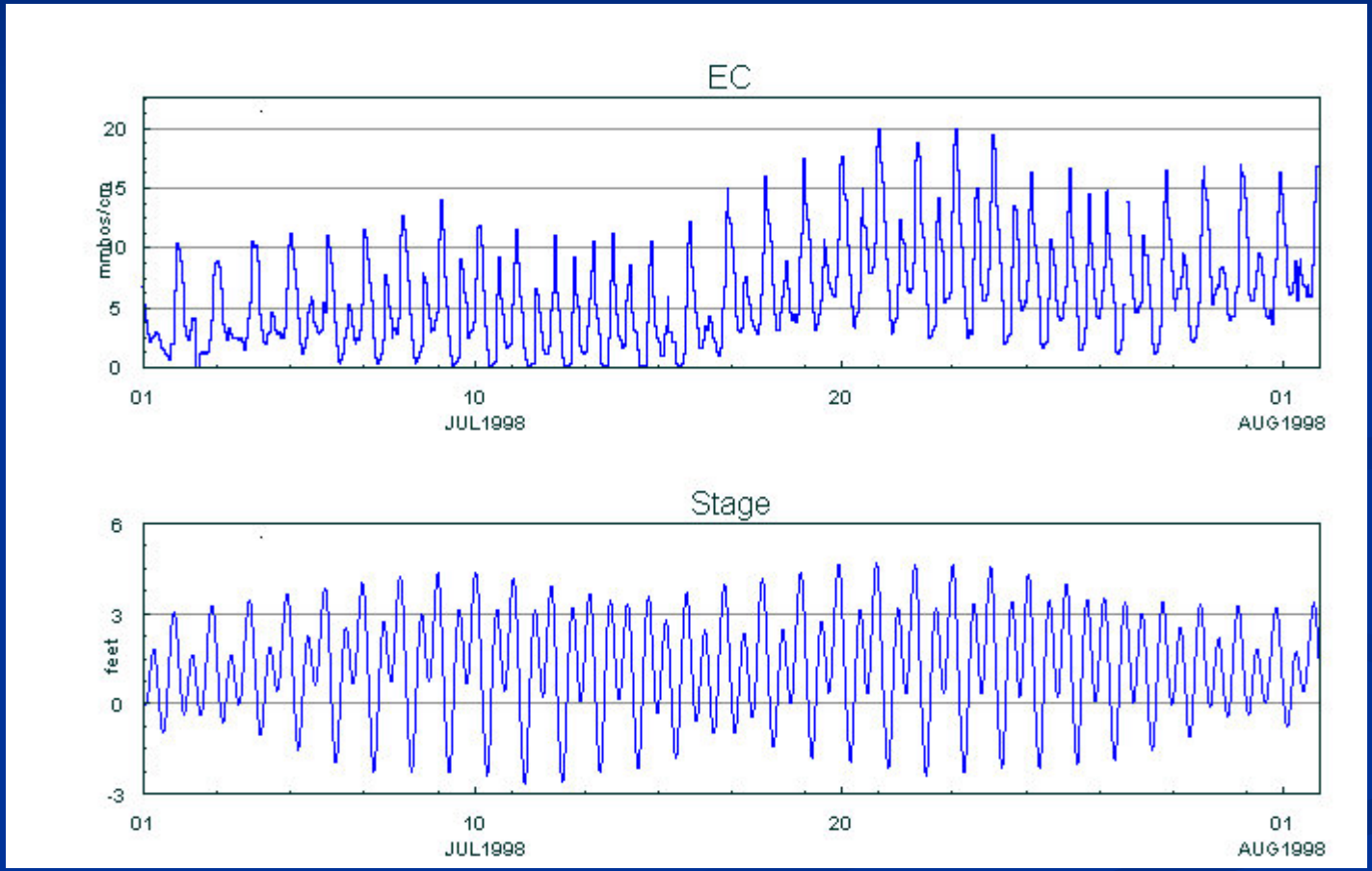


Disaggregated model for EC

- Basic idea: estimate a profile, move it back and forth harmonically

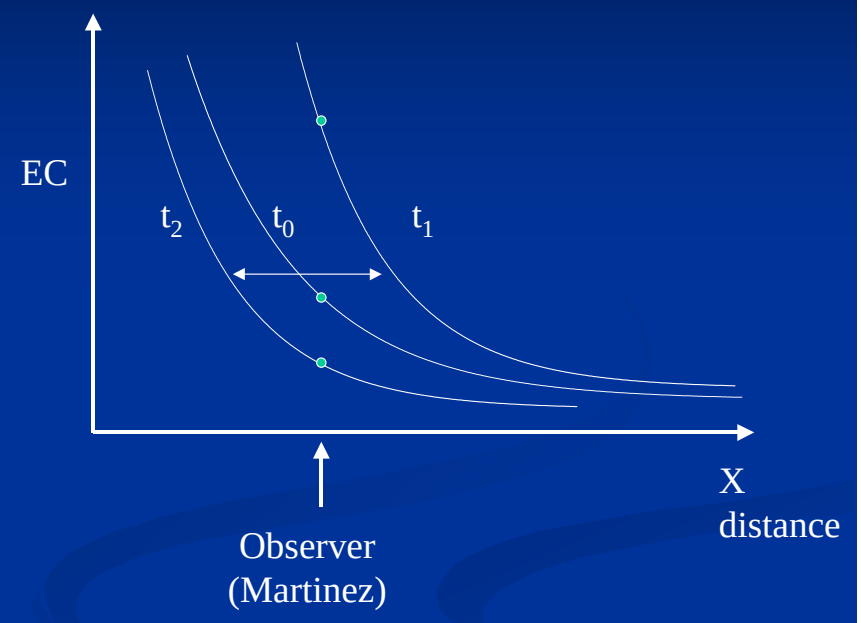


The hitch: EC is not sinusoidal



EC Model

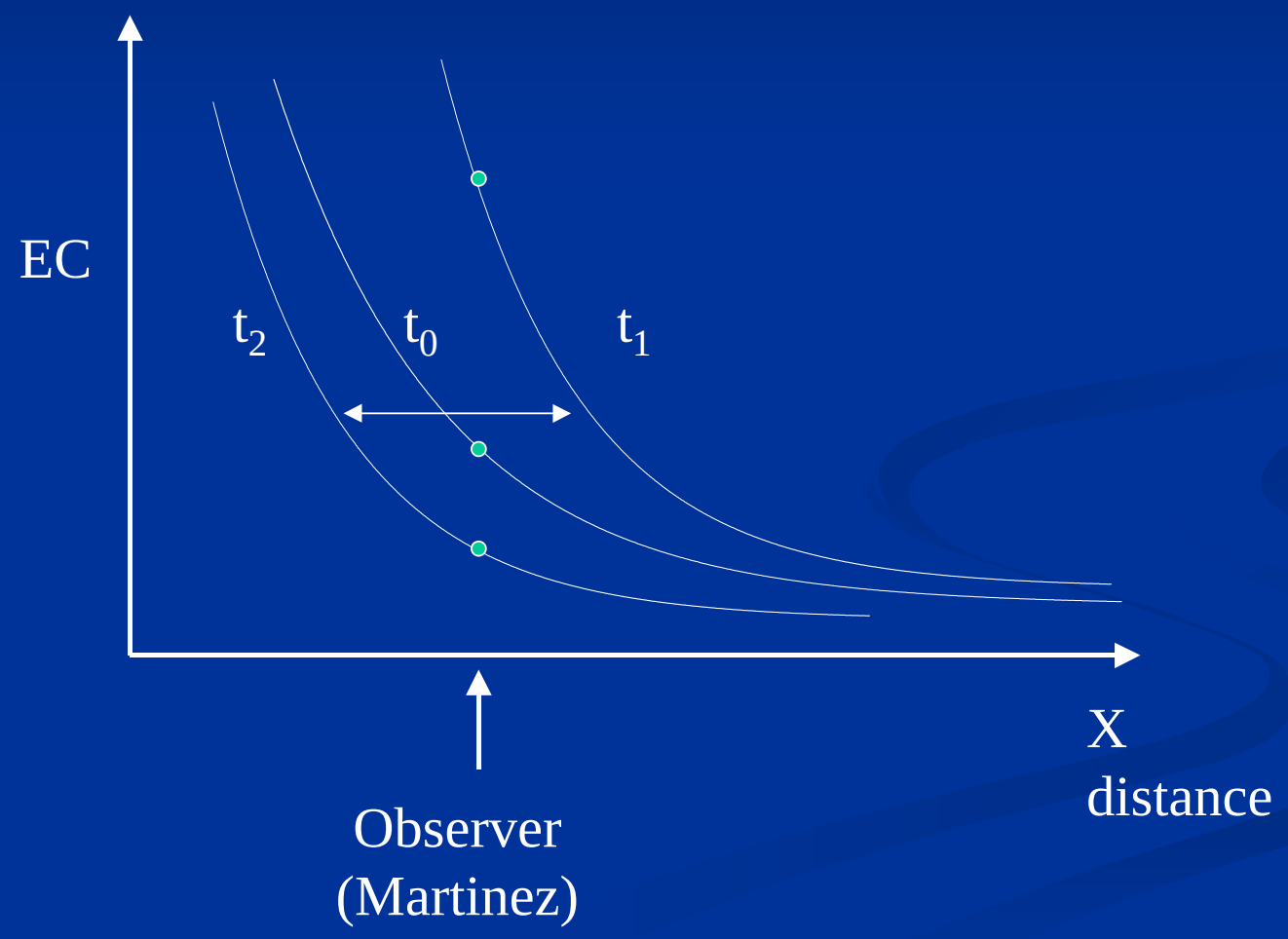
- "G-like" model to estimate EC profile
- Harmonic stage + transfer function for displacement
- Estimation is not trivial
  - Least squares is inappropriate, and leads to huge errors
  - Generalized Estimating Equations (see 2001 Annual Report)
  - Profile displacement is an embedded assumption



Exponential spatial profile from G-model derivation

Don't blame Richard!!

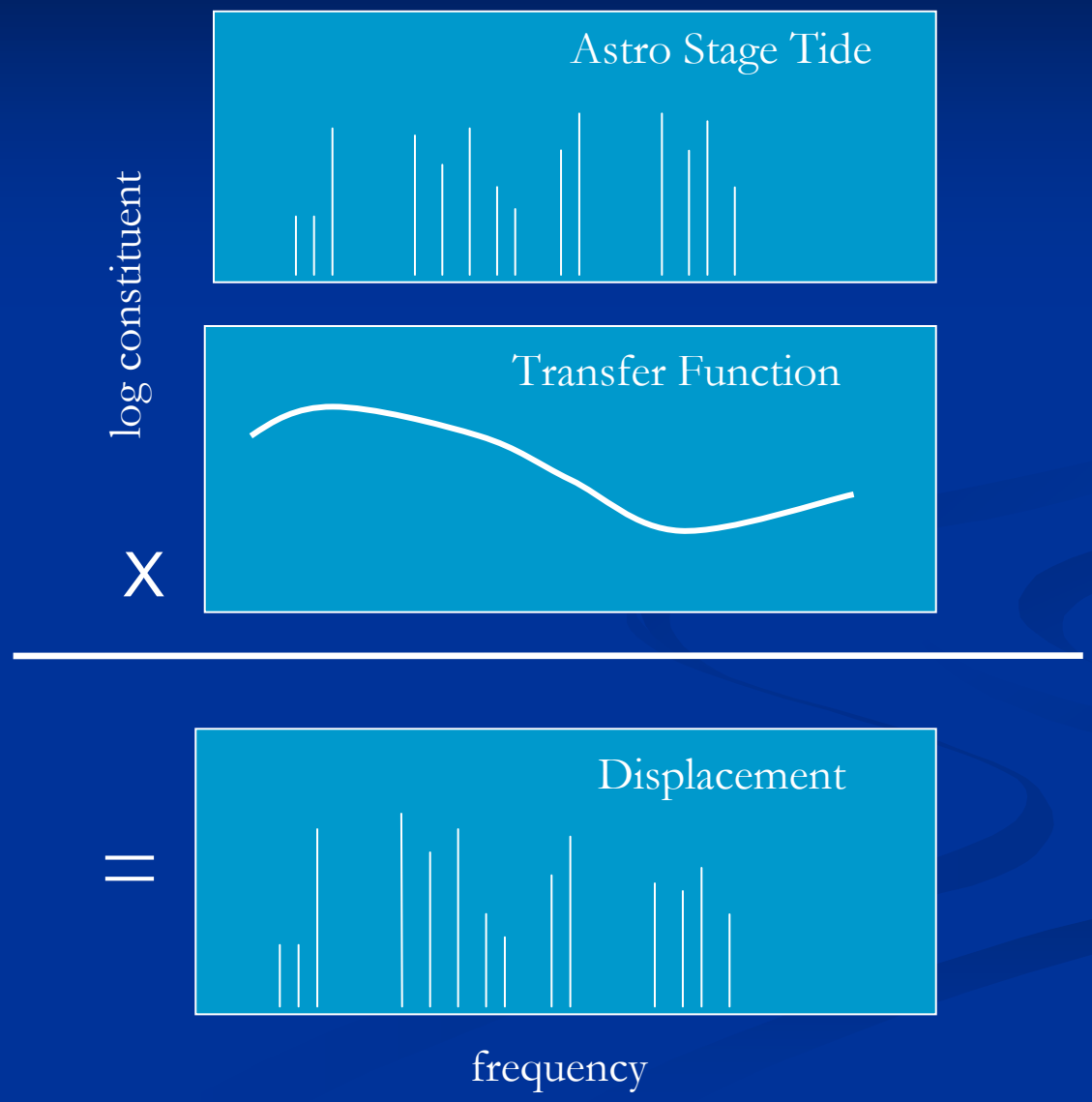
Now the shape of the tidal fluctuation is right



Displacement

- Assume advection of profile is harmonic
- Same frequencies as stage and flow…so…
- Assume that displacement is the result of a linear system acting on stage
- Estimate system

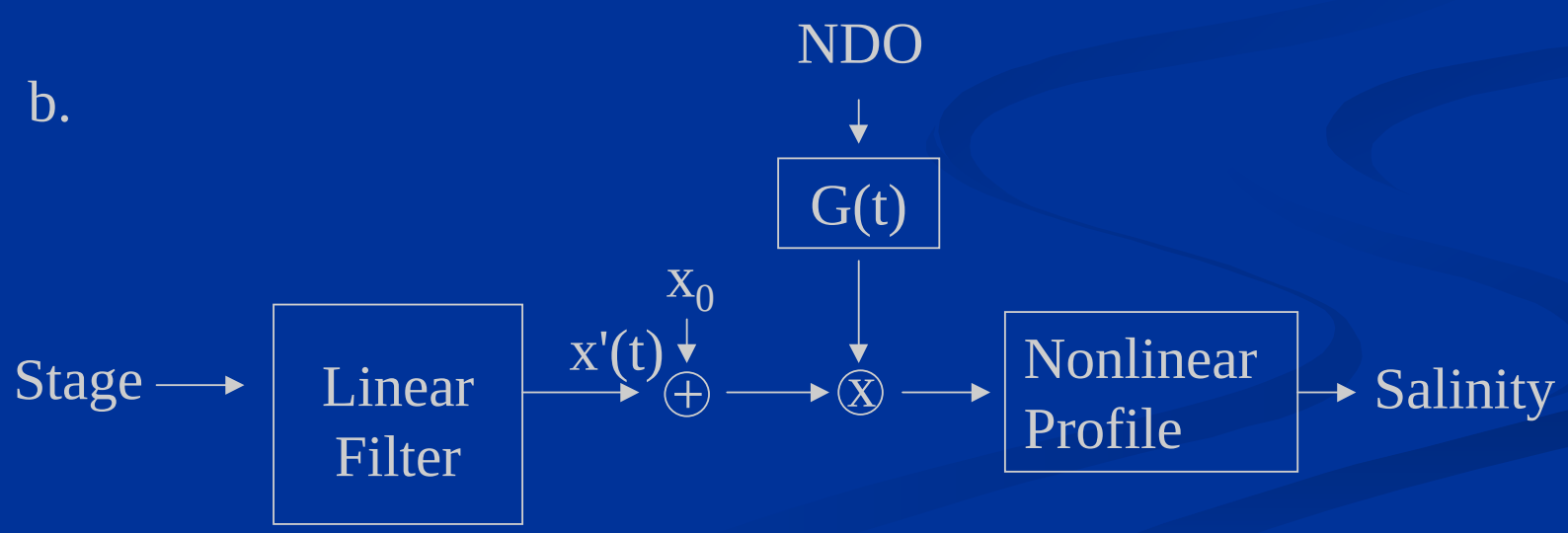
Transfer Function for Displacement



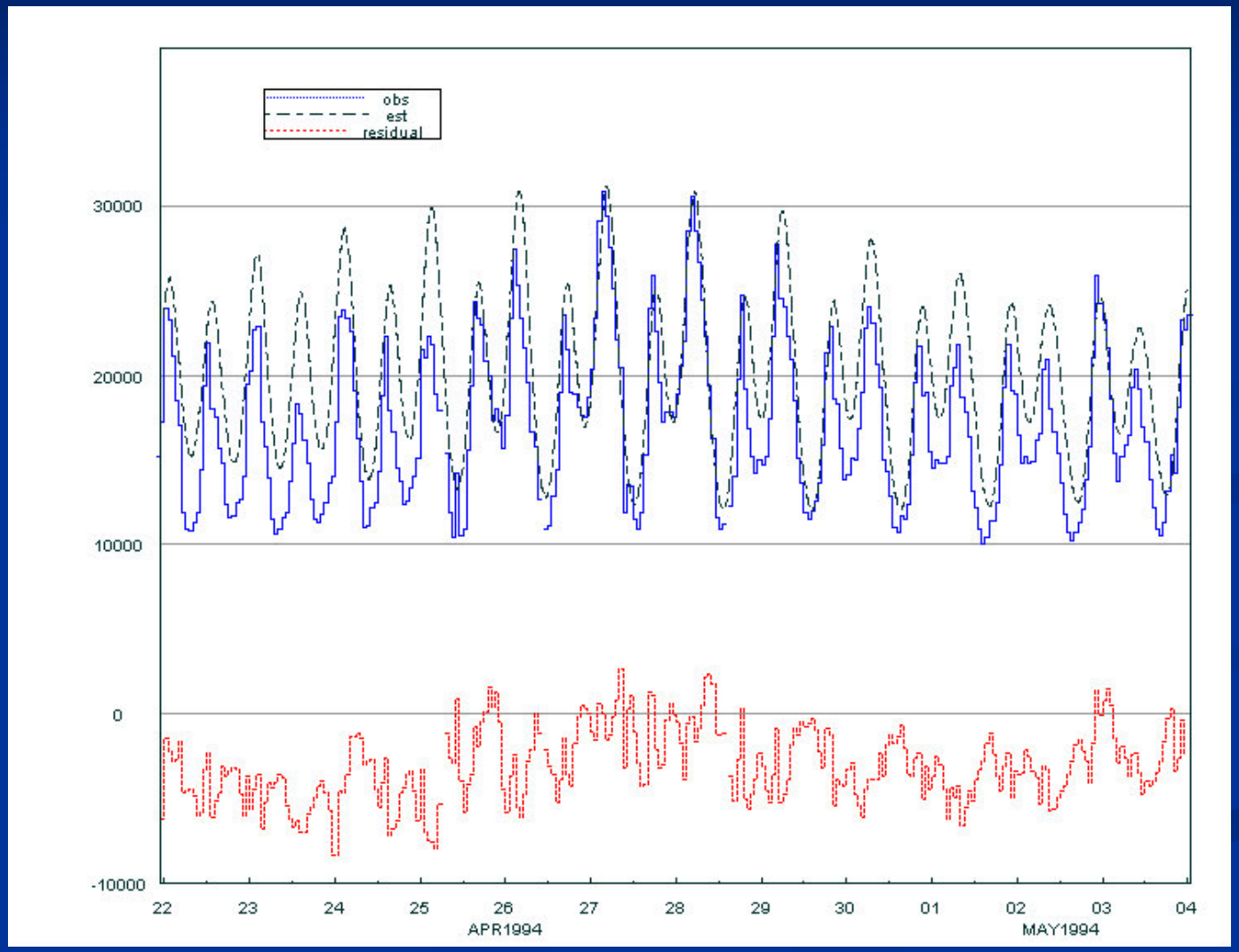
Putting it together

a.

b.

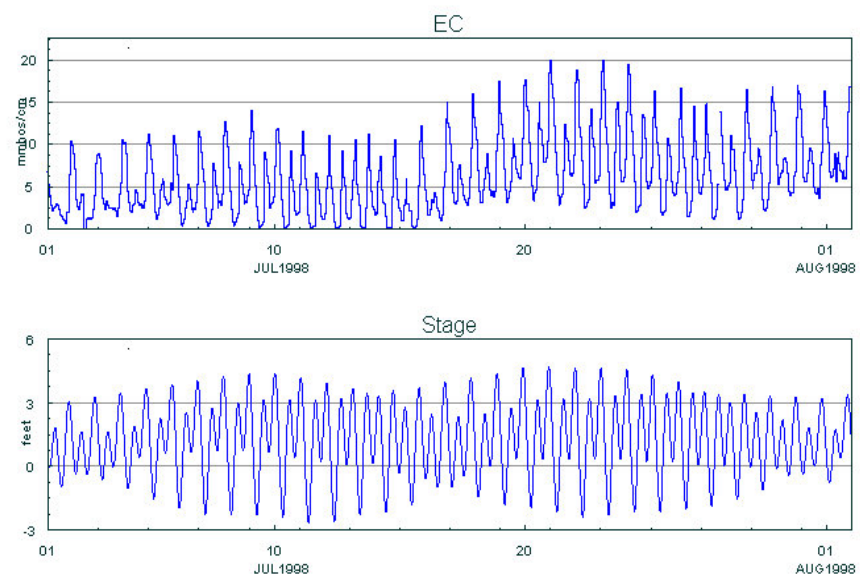


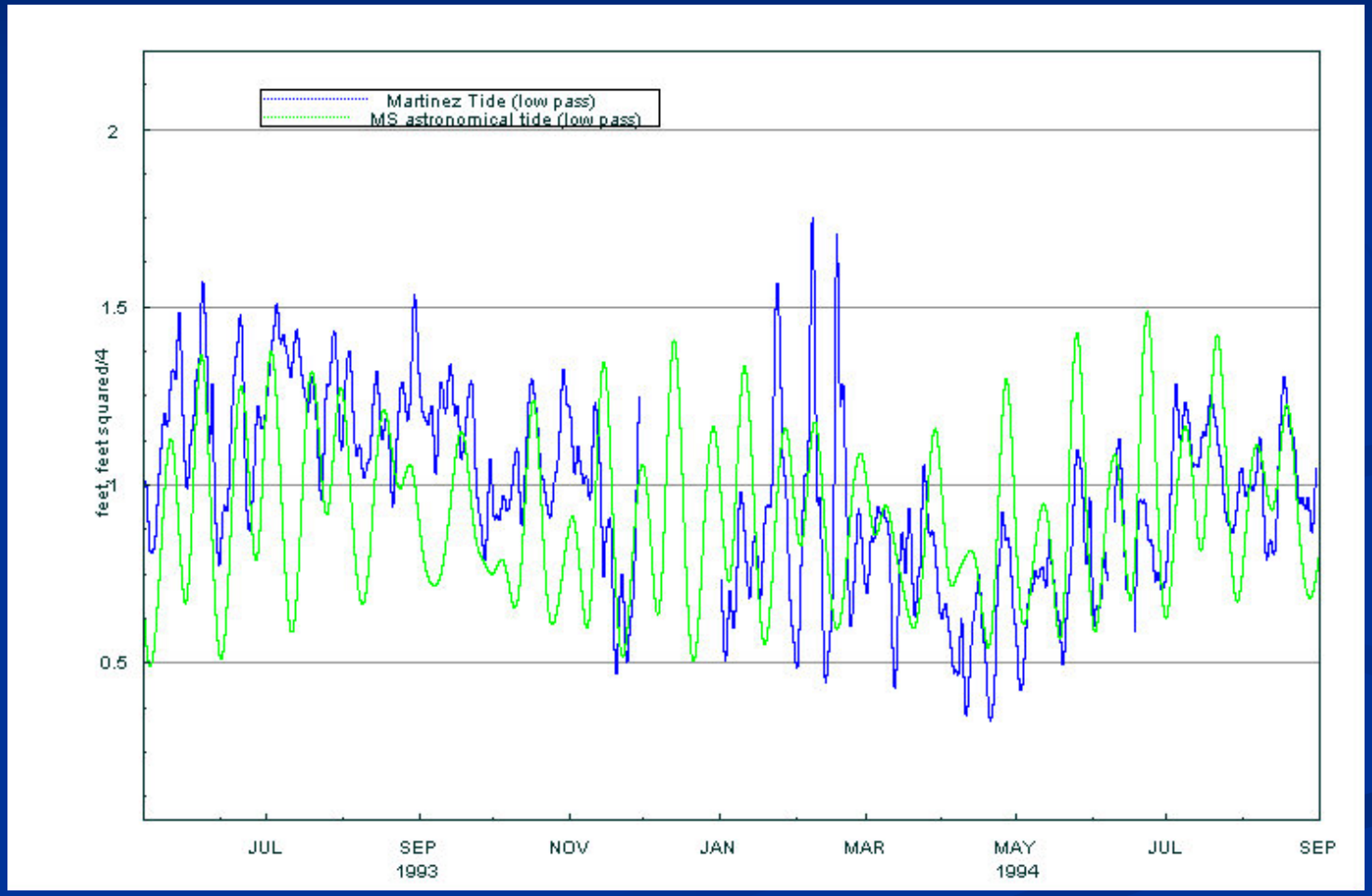
EC Model Performance

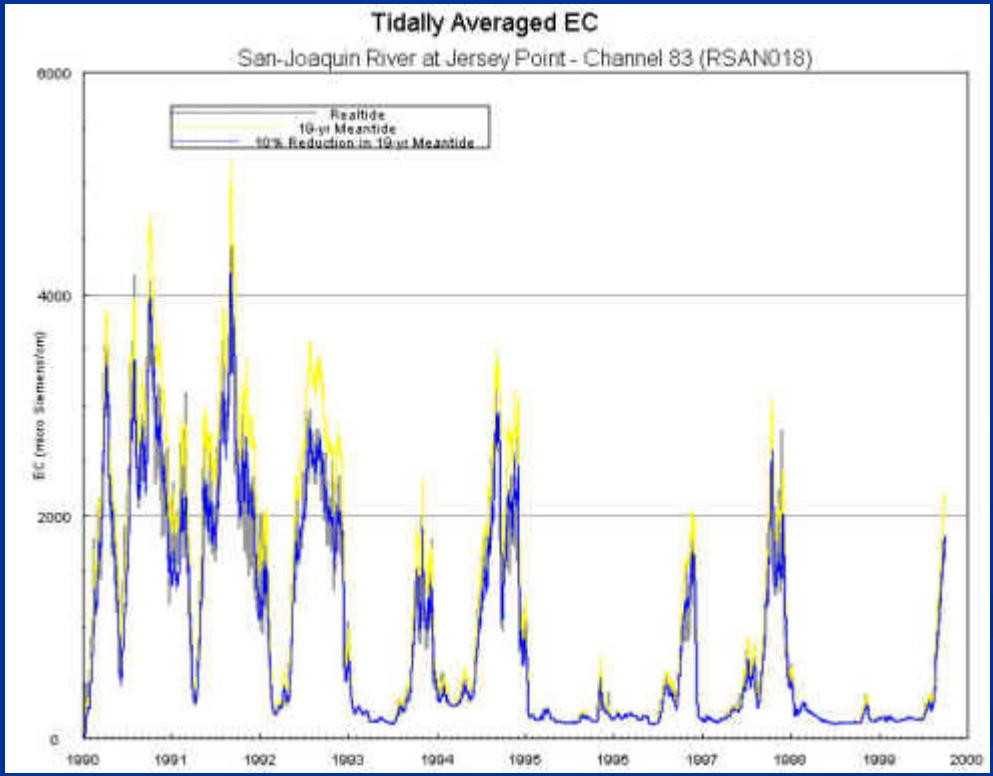


EC Model Performance

- Low-medium relative error (rms error during a validation period was 2828μmhos/cm)
- Residuals fairly uncorrelated in short term, some long term correlation
- Hard to catch quirks of EC




Martinez Tide (low pass)
MS astronomical tide (low pass)
2
1.5
1
0.5
feet, feet squared/4
JUL
SEP
1993
NOV
JAN
MAR
MAY
1994
JUL
SEP


Tidally Averaged EC
San-Joaquin River at Jersey Point - Channel 83 (RSAN018)
Realtide
10-yr Meantide
10% Reduction in 10-yr Meantide
EC (micro Siemens/cm)
6000
4000
2000
0
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000